AMBIENT HYDROCARBONS SURVEY IN THE NANTICOKE AREA, SEPTEMBER, 1980

Report No. ARB-TDA 65-80

Ontario

Ministry of the Environment

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Ambient Hydrocarbons Survey in
the Nanticoke Area,
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Technology Development and Appraisal Section
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ABSTRACT

A field program was carried out in September, 1980, at Nanticoke, Ontario to investigate the ambient hydrocarbon levels in the vicinity of the Texaco petroleum refinery. Eleven one-hour sampling periods at ground level and aloft provided samples on preconcentrating adsorbent cartridges for subsequent desorption into a gas chromatograph. Analysis was carried out for a number of aliphatics, olefins and aromatics.

In general, refinery emissions were detected on downwind samples collected within 1 km of the tank farm. The major components detected included pentanes (n-pentane, 2-methylpentane and cyclopentane), 1,3-butadiene and n-butane/butene. Lower levels of propane/propene, benzene and hexane, and traces of xylenes, toluene and nonane were also found. Thus the majority of the hydrocarbons detected were alkanes, and the only highly photochemically reactive hydrocarbon found in significant concentrations downwind of the refinery was 1,3-budadiene.

ACKNOWLEDGEMENTS

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Thanks are also due to the Environmental Applications Group of Toronto for providing meteorological measurements throughout the study period.

This report was prepared by S. Onlock of Moniteq Ltd., under contract to The Special Studies Unit of the Air Resources Branch, who was also in charge of coordinating the study.

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1. INTRODUCTION

It has been recognized that a petroleum refinery (Texaco) operating near a fossil fuel fired generating station (Ontario Hydro) has the potential under certain meteorological conditions to produce atmospheric problems downwind due to the mixing of hydrocarbons (from the refinery) and nitrogen oxides (from the generating station), which under the influence of sunlight can form photochemical oxidants such as ozone and peroxyacetyl nitrate, as well as elevated conversion rates of sulfur dioxide to sulfates. Although the Texaco refinery at Nanticoke is a modern facility designed to keep hydrocarbon emissions to a minimum, an estimate of the emission rates as well as identification of the components emitted is necessary since the extent of oxidant formation and sulfur dioxide oxidation depends on the relative amounts of nitrogen oxides and hydrocarbons, as well as the type of hydrocarbons present.

Preliminary studies to determine background hydrocarbon concentrations and also any contribution from the refinery and other local sources were carried out by the Ontario Research Foundation[1] (ORF, 1977) and the Technology Development and Appraisal Section of the Air Resources Branch (1979)[2]. The ORF study attempted to measure hydrocarbon levels by collecting ambient air samples in multi-layered bags, followed by concentration of an aliquot onto an adsorbent for desorption into a gas chromatograph equipped with a flame ionization detector. However, this method met with little success due to problems encountered in preserving ambient level samples in bags and design problems in the desorption unit. Subsequently, a method using direct adsorption of hydrocarbons onto a preconcentrating cartridge was developed by the Monitoring and Instrumentation Development Unit of the Air Resources Branch. The ground level cartridges were exposed using the NUTECH sampler and airborne samples were collected using a helicopter.

In general, the preliminary survey showed no clear difference in individual hydrocarbon concentrations measured upwind and downwind of the refinery. There was also contamination, by exhaust, of the airborne samples collected by helicopter, and difficulty in positioning ground level samples within the refinery plume. Several shortcomings in the sampling and analysis methodologies were illustrated, and the recommendations made for improvement were incorporated into the 1980 field program. The improvements consisted of:

1) On site meteorological measurements using a tethersonde instrument package, to assist in accurately locating the ground-level samplers within the plume, and to provide high-resolution wind measurements required for the calculation of hydrocarbon fluxes.

2) The placement of the ground level samplers was assisted by real-time measurements of the hydrocarbon plume obtained by mounting a portable photo-ionization detector and condensation nuclei counter in a vehicle which relayed the position of plume while traversing in an approximately cross-wind direction.

3) The deployment of remotely activated airborne sampling platforms suspended from a tethered balloon, to avoid sample contamination during the vertical concentration measurements.

4) Collection of duplicate ambient samples to check the precision of the method.

5) Development of a better sampling methodology for measurements of the headspace in the storage tanks.[5]

This report consists of a presentation and discussion of the ambient data collected by the Technology Development and Appraisal Section of the Air Resources Branch during the September 1980 study. The storage tank headspace measurements will be detailed in a separate TDA report.[5]

2. EXPERIMENTAL

2.1. Gas Chromatographic Analysis of Cartridges

The ambient air was sampled by drawing air through a glass cartridge packed with a Molecular Sieve 5A adsorbing medium, followed by a short length of silica gel, at a constant measured flow rate for one hour. The analysis of the desorbed hydrocarbons from the exposed cartridges was performed by a Hewlett-Packard Gas Chromatograph (HP 5840A) and a microprocessing unit (HP 18850A G.C. terminal). Operating parameters were monitored automatically by the microprocessing unit once the program was entered.

The column consisted of 9.0 metres of stainless steel tubing, 2 mm I.D., packed with 5% SP-1200/1.75% Bentone 34 on 100/120 Supelcoport. Temperature programming was used with nitrogen as the carrier gas flowing at 35 ml/min with the temperature at 10^{o}C for 2.5 minutes, then ramped at 20 ^{o}C/min up to 175^{o}C and held for 3.75 minutes. A flame ionization detector (FID) at a temperature of 250^{o}C was used to detect the hydrocarbons.

The system was calibrated by injecting a hydrocarbon mixture of known concentration onto cartridges followed by desorption onto the column to determine a response factor for each component. This factor was then applied to each compound found in the samples desorbed from the cartridges with correction for sample volume. The results are reported as micrograms per cubic meter (ugm^{-3}) of each component.

Similar G.C. retention times made resolution of certain groups of compounds impossible. The compounds that could not be differentiated were; ethene/acetylene, propane/propene, n-butane/n-butene/2-butene, 2-methyl pentane/cyclopentane and m-xylene/p-xylene. The values reported for these combined peaks represent the total concentrations detected for the group. It should also be noted that breakthrough of methane and ethane was too large to permit determination by the present cartridge method.

2.2 Collection of Ground Level Samples

The ground level samples were collected by drawing the air sample through a cartridge using portable NUTECH pumps. Limiting orifices downstream of the cartridge were used to control the flowrate at approximately 45 ml/min. The

limiting orifices were calibrated using three different NUTECH samplers under cartridge load conditions. The flow rates were measured with a TELEDYNE - HASTING Mass Flow Meter (500 ml/min). The entire set of limiting orifices were found to have an average flow rate of 42 $\pm$ 2 ml/min, independent of the load conditions and NUTECH pump used.

The placement of the samplers was determined by the wind direction as indicated by the tethersonde system and the location of the hydrocarbon plume as detected by the traversing vehicle. Once the plume was located the downwind samples (usually 8 or 9) were spread out evenly over approximately 1 km perpendicular to the wind direction. This usually meant that the samplers were set up along the side of one of the concession roads bordering the refinery. Care was taken to avoid contamination by placing the samplers well upwind of roads, portable generators, and other local sources. Background samples were collected several kilometers upwind of the refinery, again well away from local hydrocarbon sources. Duplicate background samples were collected on most days.

The cartridges were then inserted into the NUTECH sampling manifold and remained capped until the sampling period began. All pumps were activated at approximately the same time (within 2 minutes of each other) and allowed to run for one hour. During the sampling period the head pressure on the NUTECH pump was checked periodically to ensure that a steady flow was maintained. Upon completion of the sampling period the cartridges were capped and stored in glass jars for transportation to the laboratory in Toronto. Care was taken to avoid contamination by wearing disposable gloves whenever cartridges were being handled.

Some of the NUTECH samplers were equipped with 'U' shapped sampling manifolds which allowed for the collection of duplicate samples at specific locations. These double manifolds were used to expose cartridges in parallel to check the precision of the molecular sieve collection method, and also for the parallel collection of samples on cartridges packed with TENAX adsorbing medium for an evaluation study conducted by the Hazardous Contaminants and Research Planning Unit of the Air Resources Branch.

2.3 Ground-Level Plume Tracking

A vehicle equipped with instrumentation to make real-time hydrocarbon measurements while traversing cross-wind at the perimeter of the refinery was used to delineate the plume of emissions from the refinery. The instrumentation consisted of a portable photo-ionization detector (PID) to detect various hydrocarbons, a condensation nuclei counter (which had proven useful for plume tracking in a study by Westberg[3] conducted at an older U.S. refinery), a solar radiometer and strip chart recorders to record the data.

The PID (H.NU Systems Model #P1 101) was not calibrated because the response of the unit varies significantly for different hydrocarbons (for exmaple the response for pentane is approximately one-tenth that for benzene). However, it proved to be a very useful tool for defining the plume location and making qualitative estimates of the emission levels.

2.4 Airborne Sample Collection

The measurement of the vertical concentration distribution within the hydrocarbon plume was obtained by suspending three sampling platforms from a large tethered balloon at heights predetermined by the requirements for mathematical modeling of the refinery emissions (usually at 100, 60 and 30 m). The sampling platforms consisted of a small battery powered pump and remotely activated ON/OFF circuitry, fastened to a lightweight platform that was secured to a line hanging from the balloon. The sampling cartridge was connected to the pump with a short piece of tygon tubing. The flow through the cartridge was measured before the sample was elevated, and again after sampling. Flow rates were typically in the range of 40-50 ml/min. The samples were controlled remotely to ensure that a one-hour sample was collected coincident with the ground level sampling. The height of the different sample platforms was measured throughout the sampling period by triangulation using two theodolites separated by 200-300 m. The height of the platforms was found to vary about $\pm$ 15 m vertically about the average reported height.

2.5 Meteorolgoical Measurements

The meteorological measurements were obtained by a tethersonde instrument package that was provided by an external consulting company (The Environmental Applications Group of Toronto). The data and detailed measurement methodology are presented in their report[4]. Briefly, the tethersonde provides measurements of wind speed and direction, wet and dry bulb temperature, height and relative humidity every 30 seconds. The tethersonde was raised near the refinery to provide high resolution local meteorological data required for the placement of the ground samplers and the calculation of hydrocarbon fluxes across a vertical plane downwind of the refinery. The sequence of vertical measurements during the hour-long sampling was; 5 minutes at 5 meters, 10 minutes at 10m, 15 min at 50m, 10 min at 10m and 5 min at 5m, then repeat.

The tethersonde could not be used when the wind speed exceeded 10 m/s. On these days the metoerological data was obtained from a portable meteorological (MRI) sensor mounted on a 10m tower on Texaco property.

2.6. Source Assessment Measurements.

The Source Assessment Unit of the Air Resources Branch also made some measurements of the headspace gases in a number of different storage tanks at the Texaco refinery in late September. The results of these mesurements will be presented in another report from the Technology Development and Appraisal Section of the Air Resourcs Branch.[5]

3. RESULTS

3.1 General Results

Eleven hours of ground level sampling were completed over seven days during the period September 3 to September 12, 1980. During this period five hours of measurements of the vertical distribution of hydrocarbons downwind of the Texaco refinery were also obtained.

The meteorological and sampling conditions for each sampling period are described in detail in Appendix 1 and are summarized in Table 1. The concentrations of the individual hydrocarbons detected in each of the cartridges (including ground level downwind, upwind, and aloft, along with blanks), as well as the concentration of total hydrocarbons for each run, are presented in Tables 2 -11. The locations of the downwind, upwind and aloft samplers for each day are displayed on Maps 1-8. The crosswind profiles (usually about 10 transects) obtained from the photo-ionization detector (PID) have been averaged over the sampling period to provide a plot of relative intensity as a function of crosswind distance. Since the PID was not calibrated (see above) the relative intensity in arbitrary units was obtained by comparing the sensitivity and span settings of the instrument from day to day. These crosswind profiles are plotted for each run in Figures 1-9. The total hydrocarbon concentrations detected in the ground level samples are also plotted as a function of crosswind distance on these same figures.

The Condensation Nuclei Counter was also in operation during the crosswind profiling, however, the signal was very noisy and it was not possible to distinguish background from in-plume measurements. There was also a malfunction in the solar radiometer after the first day. The data from these two instruments have not been included.

The results of the meteorological measurements (including general meteorological observations) using the tethersonde system are presented in a report by the Environmental Applications Group to the Air Resources Branch[4]. On two days (Wednesday Sept. 10, and Thursday Sept. 11) strong winds prevented operation of the tethersonde system. The wind speed and direction for these days was obtained from the portable sensor mounted on a 10m tower located at the Northern edge of Texaco property. The results are presented in Table 12.

3.2 Daily Results

Four sets of samples collected on two different days on Concession Road III (less than .5 km from the tank farm) north of the refinery show a plume 400m wide near the western edge of the tank farm. The crosswind profiles as detected by the photo-ioinization detector have been averaged over the hour-long sampling periods to illustrate the placement of ground level cartridges with respect to the plume boundaries. Figure 2 shows the total concentration (in ug/m^3) of hydrocarbons detected on each of the ground level cartridges as a function of their crosswind position for the first run on Sept. 4. The sampling conditions consisted of warm sunny weather with light SSW winds, with wind speeds increasing during the afternoon. A relatively flat plume was observed with four cartridges in the peak area (total concentrations of 650-800 ug/m^3), two in the tailing regions (270 and 380 ug/m^3), and one outside the plume (14 ug/m^3). The major constituents (see Table 3) of the plume were found to be pentanes (n-pentane, methyl pentane and cyclopentane), 1,3 butadiene, hexane, and an undertermined compound believed to be a pentane due to its retention time on the gas chromatograph. Some butanes and propane/propene were also detected on some of the cartridges. There were also traces of some of the higher molecular weight compounds including xylenes, toluene and trimethyl benzenes, although the trimethyl benzenes were also observed in the cartridge exposed upwind of the refinery. The total hydrocarbon concentration measured upwind was 51 ug/m^3 which consisted of 1,3,5 and 1,2,4 trimethyl benzene. Due to problems with the elevated platforms, only one airborne measurement (at 35m) was made. The total concentration of 190 ug/m^3 consisted of butane, butenes, butadiene and pentanes. None of the heavier components were observed.

The second run on Sept. 4 (Fig. 3, Table 4) shows a narrower, well-defined plume in the same area. The cartridges exposed near the centre of the plume show high concentrations of total hydrocarbons (1200, 2900 and 1000 ug/m^3), while the tail areas fall off quite quickly. The major constituents of the plume were again found to be pentanes, 1,3 butadiene and some butanes/butenes and propane/propene. Traces of hexane, benzene and some of the other heavy components were again observed. Trimethyl benzene again appears in both up- and downwind cartridges. The components found on the airborne samples collected at 100, 60 and 15m above ground (T1, T2, T3 in Table 4) in the centre

of the plume contain similar components to those on the ground. The total hydrocarbon concentration decreases with height (Fig. 10). However, the relative amounts of different components remain constant (Fig. 11).

A definite plume was also observed on Concession Road III downwind of the refinery on Sept. 8 under similar sampling conditions. The plume was again observed to be about 400m wide. During both runs the plume was found to be coming from the western edge of the refinery. Two cartridges were found to have about 1000 ug/m^3 (Tables 6 and 7, Figures 5 and 6) at the centre of the plume with the tail regions falling off quite quickly. Again the major constituients of the emissons were found to be butadiene, butane/butene and pentanes. Traces of benzene, toluene and xylenes were also detected. Two upwind cartridges were exposed during each run. The upwind cartridges exposed during the first run were found to have total hydrocarbon concentrations of 163 and 80 ug/m^3 consisting of mainly trimethyl benzenes. The upwind samples collected during the second run were somewhat cleaner at 45 and 14 ug/m^3 total, but trimethyl benzene was again discovered. Trimethyl benzene was also discovered on one of the blank cartridges, suggesting that it may have originated due to contamination during handling.

The elevated samples (T_A, T_B, T_C at 100, 60, 20m respectively in Tables 6 and 7 - see also Fig. 12) were not collected at the centre of the plume, however, the total concentration decreased with height, and the relative amounts of the different components remained constant.

The sample collected on September 5 (Table 5) is of little use, because as the sampling began the wind shifted from SSW to WSW causing the refinery plume to miss the ground level samplers. However, trimethyl benzene is the major component found in 11 cartridges, including the upwind and blank samples.

On September 10, the sampling conditions consisted of cool NW flows under sunny skies. The PID was traversing along Concession Road #2 from the eastern fence line to the western fence line of the Texaco property (on Fig. 7 the origin of the the distance axis represents the eastern edge of Texaco property). The ground level samplers were located in an arc on the southeast corner of Texaco property (see Map 5). No definite plume was observed, however, the PID did pick up some hydrocarbons along Concession Road II, and some of the cartridges

detected total hydrocarbon concentrations as high as 200 ug/m^3 (Table 8). During this run cartridges were exposed in parallel to check the precision of the sampling method. Three pairs of parallel cartridges were analysed (4, 4a, 5,5a and 6,6a, in table 8) and the concentrations of individual components as well as the total concentrations were found to agree within a factor of 2 in most cases. These results are plotted in Fig. 13. Similar results were obtained for two pairs of cartridges collected on Sept. 12 (Table 11, Fig. 14).

Two sets of cartridges were exposed on Sept. 11 (Tables 9, 10). The winds were from the west at 8-12 m/s, which prevented tethersonde operations. Cartridges were exposed at two downwind distances, one set on the abandoned runway about 0.5 km from the tank farm, and the other along Sandusk road about 2 km away (Maps 6 and 7). The PID was unable to detect any plume in either location. During the first run one cartridge near the tanks had a total concentration of 250 ug/m^3 consisting of butane/butene, propane/propene and some heptane and nonane. One of the cartridges along Sandusk road had a total of 155 ug/m^3 hydrocarbons consisting of heavier components including heptane, nonane, xylenes and some methyl pentane and cyclopentane. The remaining cartridges indicated total hydrocarbon concentrations similar to, or less than, the 80 ug/m^3 detected in the upwind samples. The upwind sample again exhibited higher levels of trimethyl benzene. During the second run no significant levels were detected on Sandusk road, however, three of the near-field cartridges had total concentrations of 158, 180 and 340 ug/m^3 comprised of pentanes, hexanes, benzene, xylene and some trimethyl benzene.

Two sets of samples were collected on September 12, however problems with the gas chromatograph caused most of the samples to be lost.

4. DISCUSSION OF RESULTS

4.1 Refinery Contribution to Ambient Hydrocarbons.

During the 1979 study of ambient hydrocarbon concentrations in the vicinity of the Texaco refinery at Nanticoke there were no general differences in levels observed up- or down-wind of the refinery.

The results from the 1980 survey, however, show a definite well-defined refinery plume that was detected approximately .5 km away from the edge of the tank farm during four one-hour periods of the study.

On other days a well-defined plume was not evident, however, some of the components were still found at higher concentrations downwind of the refinery. The upwind cartridges were generally found to be relatively hydrocarbon-free, with the exception of trimethyl benzene, which was often found in equal concentrations up- and down-wind of the refinery. With the exception of one cartridge, no significant refinery effect could be detected in samples collected more than 1 km away from the refinery.

The major constituients of the refinery emissions were determined to be pentanes (including n-pentane, 2 methyl pentane, cyclopentane, 3 methyl pentane and methyl cyclopentane), 1,3 butadiene, n-butane/n-butene/2-butene and propane/propene. Benzene, hexane, and xylenes were found in lower levels along with traces of nonane, cyclohexane and toluene. Some "unknown" compounds that were not taken into account in the calibration mixture were also occasionally found, however they remain unidentified.

It must be noted that during much of the sampling period, conditions were such that hydrocarbon emissions from the tanks would be expected to be near their maximum due to strong solar radiation and warm ambient temperatures. It must also be noted that there may have been an upset condition at the refinery in that some of the storage tanks in the north-west section of the tank farm may have had pressure relief valves that were malfunctioning during the survey period causing the tanks vent to the atmosphere prematurely (R.D. Cameron, private communication).

4.2 Precision Tests

Five sets of duplicate samples were collected to check the precision of the sampling method. The results were found to be generally reproducible within a factor of two for the individual components as well as for the total amount of hydrocarbons reported (Figs. 13, 14).

4.3 Mathematical Modeling

For the four sampling periods in which a well-defined refinery plume has been observed, it has been possible to construct crosswind and vertical profiles of the hydrocarbon concentrations using the cartridge results. These may be used, in conjunction with the high resolution meteorological data provided by the Environmental Applications Group, and the time averaged crosswind profiles from the photo-ionization detector, to calculate the net hydrocarbon fluxes across a vertical plane perpendicular to the wind direction. Such a calculation will be attempted by the Mathematical Modelling Unit of the Air Resources Branch.

CONCLUSIONS AND RECOMMENDATIONS

During the 1980 study of hydrocarbons in the Nanticoke area it was possible to determine the contribution of the Texaco refinery to ambient levels. The approach of using a tethersonde to measure concentrations aloft, together with a traversing vehicle with a photo-ionization detector, allowed the extent of the entire refinery plume to be identified on several occasions. These data will be useful for estimates of hydrocarbon emission rates from the refinery.

The major constituents of the refinery emissions during the sampling period were determined to be pentanes (including n-pentane, 2 methyl pentane, cyclopentane), 1,3 butadiene, n-butane/butene/ 2-butene and propane/propene. Lower levels of benzene, hexane and xylenes, and traces of toluene, nonane and cyclohexane were also found.

The analysis for hydrocarbons using a speciation method to identify the individual components provides useful information ragarding the implications of emissions on potential photochemical smog problems. The results from this study indicate that the majority of the components detected in the refinery emissions were alkanes which are considerably less reactive than olefins or aromatics. The only potential highly reactive hydrocarbon definitely detected in significant concentrations downwind of the refinery was 1,3 butadiene. Some butenes also may have been present, but the analysis methods did not allow these to be resolved from butane. Whether or not the measured levels are sufficiently high to cause downwind photochemical smog problems will require a detailed aerometric analysis of ozone concentrations in the area. Mathematical modelling simulations of smog formation, employing NO_x and hydrocarbon emission rate information for the area, may provide useful information.

During the course of the field program the Texaco refinery was experiencing difficulties with pressure refief valves on some of the storage tanks. Thus it is possible that the samples collected do not represent typical refinery operating conditions.

The recommendations from this study are as follows:

1. If future hydrocarbon studies are attempted using this speciation methodology, further work should be undertaken to resolve individual components (particularly butanes from butenes) to assess the impacts of the emissions on local air quality, especially with respect to photochemical oxidant formation.

2. Using the data obtained in this program, together with a mathematical model of dispersion downwind of the refinery, an estimate should be made of hydrocarbon emission rates from the refinery. This should then be compared with similar estimates independently obtained by the Source Assessment Unit, using their tank farm headspace test results.

3. The implication of downwind elevated concentrations of certain photochemically reactive hydrocarbons, such as butadiene, aromatics, and possibly butene should be explored further by aerometric analysis of the ozone concentrations in the Nanticoke area, as well as mathematical modelling simulations of smog formation in the refinery hydrocarbons plume.

6. REFERENCES:

1) Ontario Research Foundation, "A Preliminary Study of Atmospheric Hydrocarbons in the Nanticoke Area" Report ORF-2791-01, November 1978 (internal report to Air Resources Branch).

2) Ontario Ministry of the Environment, "The Nanticoke May/June 1979 Field Study: Dispersion and Oxidation of SO_2 in the Generating Station Plume and Ambient non-Methane Hydrocarbon Concentrations in the Area" ARB-TDA Report No. 61-80.

3) Westberg, H.H., Allwine, K.J. and Robinson, E., "Ambient Hydrocarbon and Ozone Concentrations Near a Refinery" (Lawrenceville, Ill. 1974) U.S. EPA CONTRACT #68-02-1232.

4) Environmental Applications Group Ltd., "Nanticoke Hydrocarbon Study Tethersonde Results", prepared for Air Resources Branch, October, 1980.

5) Ontario Ministry of the Environment, "Sampling of Hydrocarbon Emissions from the Texaco Refinery Tank Farm in Nanticoke, October 6 - 9, 1980", Report to be Published by Source Assessment Unit, Technology Development and Appraisal Section.

Table 1

HYDROCARBON SAMPLING AT NANTICOKE - SEPT/80
FIELD SUMMARY

Date	Meteorological Conditions	Ground Level Cartridges Upwind	Downwind	Airborne Monitoring Met Balloon	Airborne Cartriges	Plume Tracking
Wed. Sept. 3	- sunny, warm NNW flows a.m. SSW flows p.m.	1 mol. sieve	7 mol. sieve	conc. III	1 mol. sieve at 35 $\pm$ 10 m	plume found along Conc. III opposite westend of tank farm
Thurs. Sept. 4	- sunny, warm with southerly flows all day. Winds increasing in the afternoon	2 mol sieve	16 mol. sieve	conc. III	Run 1-105 m -70 m -20 m Run 2-100 m -60 m	well defined plume found consistently along Conc. III in the vicinity of NUTECH 5
Fri. Sept. 5	- light westerly flows changing to southerly at 120 hrs, then back to westerly later in the after-noon	2 mol. sieve	9 mol sieve over 1 km along conc. III	conc. III	abandoned	plume shifted east along Conc. III during sampling. Samples 1-4 may have some hydrocarbons Some plume was found near #'s 6,7 (possibly from loading area) on one pass.

Table 1 (Cont'd)

Date	Meteorological Conditions	Ground Level Cartridges Upwind	Ground Level Cartridges Downwind	Airborne Monitoring Met Balloon	Airborne Monitoring Airborne Cartriges	Plume Tracking
Mon. Sept. 8	- light south westerly flows ($3\text{-}5\ ms^{-1}$)	2 tenax 4 mol.sieve	8 tenax 18 mol. sieve	Conc.III	Run 1-100 m -60 m -20 m Run 2-110 m -85 m -25 m	monitored a wide plume along Conc. II throughout the day
Wed. Sept. 10	- strong NW was found - mainly sunny and cool	2 mol. sieve	13 mol sieve			Plume along Conc. II at the eastern edge of the refinery
Thurs. Sept. 11	- strong west-erly flows - sunny and cool	2 tenax 4 mol. sieve	8 tenax 18 mol. sieve			no plume was found along Sandusk rd. or the runway. There were some hydrocarbon near the flare stacks
Fri. Sept.12	- winds for N,NE all day - overcast at cool	Run 1 - 3 mol. sieve Run 2 - 2 mol. sieve 1 tenax	Run 1-13 mol sieve 2 break-through check Run 2-9 mol. sieve 4 tenax	Run 1 Nant. Rd. Run 2 conc. II	Run 1 Run 2-95 m -60 m -25 m	- very little plume plume was found - some activity at corner of Nanticoke Rd. and Conc. II

DATE Wed. Sept. 3 TIME 1600-1700 LOCATION Concession Rd. III

Component	Sample Position- concentration (ug/m^3)														
	N 1	N2	N3	N4	N5	N6	N7	N8	N9	U1	U2	T1	T2	T3	Blank
ethene&acetylene		-				5				1					1
propane&propene		1				-				1					-
isobutane		-				-				-					-
nbutane,nbutene,2butene		5				198				12					246
1,3-butadiene		-				18				-					-
unknown		-				77				-					-
pentane		-				80				5					-
unknown		-				18				-					-
2-methylpentane,cyclopentane		-				73				-					-
3-methylcyclopentane		-				29				-					-
hexane		-				16				-					-
methyl cyclopentane		-				15				-					-
cyclohexane		-				10				1					-
unknown		-				-				-					-
2,2,4-trimethylpentane		-				-				-					-
unknown		-				-				-					-
heptane		-				-				-					-
unknown		-				-				-					-
benzene		-				4				-					-
unknown		-				-				-					-
unknown		-				6				-					-
toluene		-								-					-
unknown		-				-				-					-
nonane		-				9				-					-
ethyl benzene		-				4				-					5
m-xylene&p-xylene		-				6				-					3
o-xylene		-				8				-					4
1,3,5 trimethyl benzene		9				57				-					5
1,2,4 trimethyl benzene		9				47				19					44
TOTAL		24				680				39					308

Table 2: Cartridge Analysis Results

DATE Sept. 4 Run 1 TIME 1300-1400 hrs LOCATION Concession Rd III

Component	Sample Position- concentration (ug/m^3)							30 m							
	N1	N2	N3	N4	N5	N6	N7	N8	9	U1	U2	T1	T2	T3	Blank
ethene&acetylene	-		2	1	1	-	2	1		1		1			2
propane&propene	-		5	1	-	75	40	21		-		1			-
isobutane	-		28	-	-	-	606	317		-		-			-
nbutane,nbutene,2butene	-		-	-	-	85	-	-		2		68			-
1,3-butadiene	6		25	68	110	90	25	-		-		16			-
unknown	-		99	116	33	305	6	-		-		6			-
pentane	1		50	271	466	-	5	-		-		56			-
unknown	-		-	-	-	-	13	-		-		-			-
2-methylpentane,cyclopentane	3		24	61	61	87	11	-		-		10			-
3-methylcyclopentane	-		8	22	23	26	4	-		-		3			-
hexane	-		7	29	55	20	1	-		-		8			-
methyl cyclopentane	2		3	14	16	26	2	1		-		21			-
cyclohexane	-		1	1	2	7	1	-		-		-			-
unknown	-		-	-	-	4	1	-		-		-			-
2,2,4-trimethylpentane	-		1	-	-	4	-	-		-		-			-
unknown	-		-	-	-	-	-	-		-		-			-
heptane	-		-	-	-	-	-	-		-		3			-
unknown	-		-	-	-	-	-	-		-		-			-
benzene	1		-	8	1	2	4	-		-		-			-
unknown	-		1	-	-	-	-	-		-		-			-
unknown	-		-	-	-	-	1	-		-		-			-
toluene	1		3	2	2	2	3	-		-		-			-
unknown	-		2	-	-	-	-	-		-		-			-
nonane	-		-	9	-	-	3	10		-		-			-
ethyl benzene	1		-	1	-	-	1	2		1		-			-
m-xylene&p-xylene	1		1	2	1	1	3	2		1		-			-
o-xylene	-		1	3	1	2	2	3		1		-			-
1,3,5 trimethyl benzene	-		4	11	27	9	5	11		32		-			-
1,2,4 trimethyl benzene	-		7	15	9	15	7	17		15		-			-
TOTAL	16		272	635	808	760	746	385		53		193			

Table 3: Cartridge Analysis Results

DATE Sept. 4 **TIME** 1500-1600 **LOCATION** Concession Rd. III

Component	Sample Position- concentration (ug/m^3) 100m , 70m, 20m													
	N1	N2	N3	N4	N5	N6	N7	N8	N9	U1	U2	T1	T2	T3	Blank
ethene&acetylene	1	1	1	1	1	-	149	-		-		1	7	3	-
propane&propene	-	1	1	1	1	75	-	24		-		1	5	6	-
isobutane	-	-	1	1	-	-	-	52		-		-	9	5	-
nbutane,nbutene,2butene	-	-	9	-	-	69	-	-		-		37	193	162	-
1,3-butadiene	38	16	21	81	281	94	-	55		-		10	48	160	-
unknown	15	1	37	331	223	331	-	-		-		6	86	211	-
pentane	10	3	22	369	1672	95	-	28		-		31	168	553	-
unknown	-	-	-	14	-	13	-	-		-		-	22	54	-
2-methylpentane,cyclopentane	7	2	20	147	292	109	-	-		-		-	71	246	-
3-methylcyclopentane	3	1	4	57	117	32	-	-		-		-	23	97	5
hexane	2	-	3	42	184	14	6	4		-		5	27	86	-
methyl cyclopentane	2	1	5	29	70	41	4	-		-		18	23	70	-
cyclohexane	-	1	1	8	15	13	-	1		-		10	25	26	-
unknown	-	-	-	-	-	7	7	-		-		-	-	-	-
2,2,4-trimethylpentane	-	-	-	-	8	11	5	-		-		3	-	-	-
unknown	-	-	1	-	-	-	-	-		-		-	3	-	-
heptane	-	-	-	-	-	-	8	-		-		-	-	-	-
unknown	-	-	-	-	-	-	-	-		-		-	-	-	-
benzene	3	3	3	14	32	4	6	2		-		4	9	17	-
unknown	-	-	-	1	4	7	3	-		-		1	2	-	-
unknown	-	-	-	1	-	-	-	-		-		-	-	1	-
toluene	2	4	5	6	5	3	1	6		-		3	3	5	-
unknown	-	-	-	2	-	-	-	-		-		-	-	2	-
nonane	-	3	-	4	-	-	-	-		-		-	-	1	-
ethyl benzene	1	2	1	2	1	1	-	-		-		-	-	1	-
m-xylene&p-xylene	1	3	2	3	1	1	1	3		-		-	-	-	-
o-xylene	1	3	1	3	1	1	3	2		-		-	-	-	-
1,3,5 trimethyl benzene	15	9	-	32	-	27	2	1		39		95	127	78	-
1,2,4 trimethyl benzene	5	13	42	13	41	8	2	2		-		-	-	11	-
TOTAL	106	67	180	1162	2949	959	197	180		39		225	851	1795	5

Table 4: Cartridge Analysis Results

DATE Friday, Sept. 5 TIME 1400-1500 LOCATION Concession Rd III

Component	N1	N2	N3	N4	N5	N6	N7	N8	9	U1	U2	T1	T2	T3	Blank
	Sample Position- concentration (ug/m^3)														
ethene&acetylene	1	1	7	-	1	1	3	1		-	1				2
propane&propene	-	-	5	2	1	-	1	-		3	-				2
isobutane	-	-	-	3	-	-	-	-		-	-				-
ıbutane,nbutene,2butene	-	1	-	-	-	-	-	2		5	-				29
l,3-butadiene	-	-	-	-	-	-	-	-		-	-				-
unknown	-	-	4	1	-	-	-	-		-	-				-
pentane	-	-	-	-	-	-	-	-		-	-				-
unknown	-	-	11	-	-	-	-	-		1	-				-
2-methylpentane,cyclopentane	-	-	-	-	-	-	-	-		-	-				-
3-methylcyclopentane	-	-	3	2	-	-	-	-		-	-				-
ıexane	-	-	2	3	-	-	-	-		-	-				-
methyl cyclopentane	-	-	2	-	-	-	-	4		-	-				-
cyclohexane	-	-	6	-	-	-	-	1		-	2				1
unknown	-	-	-	-	-	-	1	1		2	-				1
2,2,4-trimethylpentane	-	-	-	-	-	-	-	-		-	-				-
unknown	-	-	-	-	-	-	-	-		-	-				-
ıeptane	-	4	4	-	-	-	-	-		-	2				-
ınknown	-	-	-	-	-	-	-	-		-	-				-
ıenzene	-	-	2	-	1	1	1	1		-	1				-
ınknown	-	-	-	1	-	-	-	-		-	-				-
ınknown	-	-	-	-	-	-	-	-		-	-				-
oluene	-	-	2	-	1	1	2	2		1	1				-
nknown	-	-	-	5	-	-	-	-		-	-				1
onane															
thyl benzene	-	-	3	-	1	6	-	-		3	4				-
-xylene&p-xylene															
-xylene	-	-	4	1	-	2	-	-		1	-				-
,3,5 trimethyl benzene	53	-	66	-	13	35	-	-		41	92				13
,2,4 trimethyl benzene	11	2	18	8	-	12	36	64		9	-				-
OTAL	65	8	139	26	18	58	44	76		66	103				49

Table 5: Cartridge Analysis Results

DATE Non. Sept. 8 **TIME** 1415-1515 **LOCATION** Concession Rd. III

Component	Sample Position- concentration (ug/m^3) 100m, 60m, 20m													
	N1	N2	N3	N4	N5	N6	N7	N8	N9	U1	U2	T1	T2	T3	Blank
ethene&acetylene	-	-	1	1	1	-	2	-	-	3	-	5	4	1	-
propane&propene	1	-	-	1	-	-	1	63	63	4	-	1	2	2	-
isobutane	-	-	-	1	1	-	-	-	10	-	-	-	-	-	-
nbutane,nbutene,2butene	4	-	7	10	-	-	-	66	-	49	-	101	80	42	-
1,3-butadiene	1	15	-	5	13	34	119	100	48	-	-	18	19	41	1
unknown	-	-	-	-	-	20	52	181	50	-	-	60	100	162	-
pentane	-	-	43	-	35	190	584	202	84	-	7	83	110	193	-
unknown	-	-	-	-	1	-	-	120	46	-	-	-	12	-	-
2-methylpentane,cyclopentane	-	6	14	-	-	42	131	120	43	-	-	25	37	59	-
3-methylcyclopentane	-	2	-	-	-	14	53	43	15	-	-	10	14	23	-
hexane	-	-	7	-	4	26	62	26	14	-	11	9	11	18	-
methyl cyclopentane	-	-	-	-	-	14	25	38	10	-	-	5	15	11	-
cyclohexane	-	-	-	-	-	3	6	11	4	-	-	-	-	-	-
unknown	-	-	-	-	-	-	3	7	-	-	-	-	-	-	-
2,2,4-trimethylpentane	-	-	-	-	-	-	-	12	-	-	-	-	-	-	-
unknown	-	-	-	-	-	1	-	13	-	10	-	-	-	-	-
heptane	-	1	2	7	17	-	3	-	-	1	24	-	-	-	-
unknown	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
benzene	-	-	2	-	-	5	16	5	3	1	-	3	5	6	-
unknown	9	-	-	1	1	-	5	4	1	-	2	-	21	-	-
unknown	-	-	-	-	2	-	6	-	2	-	-	-	6	-	-
toluene	2	6	2	2	3	4	6	6	5	2	2	9	3	4	1
unknown	-	-	-	1	-	-	-	-	-	-	-	-	2	-	-
nonane	2	-	-	1	1	-	-	-	4	5	29	1	-	6	-
ethyl benzene	-	1	-	-	1	-	1	1	1	-	4	1	-	-	-
m-xylene&p-xylene	-	1	1	1	5	1	2	1	2	-	10	3	1	1	-
o-xylene	-	-	-	-	6	-	1	1	1	-	12	1	1	1	-
1,3,5 trimethyl benzene	6	31	-	39	40	-	-	23	22	5	39	16	1	11	14
1,2,4 trimethyl benzene	-	31	5	27	40	-	-	23	10	-	21	6	-	10	-
TOTAL	25	94	84	97	171	354	1078	1066	438	80	161	357	444	591	16

Table 6: Cartridge Analysis Results

DATE Mon. Sept. 8 TIME 1615-1715 LOCATION Concession Rd. III

Component	Sample Position- concentration (ug/m^3) 110m, 85m, 25m														
	N1	N2	N3	N4	N5	N6	N7	N8	N9	U1	U2	T1	T2	T3	Blank
ethene&acetylene	-	-	-	-	2	-	3	-	4	1	2	-	-	-	3
propane&propene	-	-	-	-	-	-	1	37	75	-	-	-	-	-	4
isobutane	1	5	-	-	-	-	-	-	-	-	-	-	-	-	-
nbutane,nbutene,2butene	3	-	-	10	3	-	-	-	-	2	-	25	34	50	-
1,3-butadiene	-	22	17	-	-	30	108	133	44	5	6	14	19	27	-
unknown	-	-	-	-	-	73	179	445	53	-	-	26	115	84	-
pentane	-	21	-	-	-	116	336	414	17	-	-	30	82	109	-
unknown	-	-	-	-	-	-	34	103	38	-	-	-	-	11	-
2-methylpentane,cyclopentane	9	-	1	-	-	35	114	171	25	-	-	12	34	48	-
3-methylcyclopentane	1	-	2	-	-	14	46	62	7	-	-	3	10	16	-
hexane	-	3	-	-	-	11	40	39	14	4	-	2	7	10	-
methyl cyclopentane	5	10	3	8	7	8	27	56	10	3	1	7	10	16	3
cyclohexane	-	-	-	-	-	1	6	10	3	6	-	11	1	3	3
unknown	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2,2,4-trimethylpentane	-	-	3	-	-	-	1	5	-	-	-	1	-	1	-
unknown	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
heptane	-	1	3	9	13	14	1	2	-	1	-	-	-	-	-
unknown	-	-	-	-	2	-	-	-	-	-	-	-	4	-	-
benzene	1	-	1	1	-	6	11	19	4	-	-	1	-	4	-
unknown	-	-	-	1	2	1	2	-	1	-	-	-	-	-	-
unknown	-	-	-	1	10	7	2	-	1	-	-	-	-	-	-
toluene	4	1	7	-	1	4	6	4	3	5	2	9	3	3	-
unknown	-	1	-	1	-	-	1	-	-	-	-	-	-	-	-
nonane	-	-	-	-	2	-	3	-	-	1	-	-	-	4	-
ethyl benzene	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-
m-xylene&p-xylene	-	-	-	-	1	-	2	-	-	-	-	-	-	3	-
o-xylene	-	-	-	2	-	-	2	-	-	-	-	-	-	-	-
1,3,5 trimethyl benzene	3	1	1	2	6	5	5	-	3	7	2	9	-	24	-
1,2,4 trimethyl benzene	1	-	-	-	8	2	3	-	2	10	1	2	-	24	-
TOTAL	28	65	38	35	57	327	934	1500	304	45	14	152	319	438	13

Table7: Cartridge Analysis Results

DATE Wed. Sept. 10 **TIME** 1430-1550 **LOCATION** South West Corner of Texaco Property

Component	Sample Position- concentration (ug/m^3)														
	1	2	3	4	4A	5	5A	6	6A	7	8	9	U1	U1A	Blank
ethene&acetylene	2	4	4	-	-	1	-	-	1	1	-	2	-	2	-
propane&propene	1	32	3	-	1	-	-	-	-	-	-	-	-	-	-
isobutane	-	-	7	-	-	-	-	2	-	-	-	-	-	-	-
nbutane,nbutene,2butene	76	-	-	41	72	-	-	46	-	-	31	-	18	2	-
1,3-butadiene	-	22	15	-	-	7	6	-	8	3	-	-	-	-	-
unknown	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
pentane	97	6	22	-	2	-	-	-	-	-	-	-	-	-	-
unknown	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-methylpentane,cyclopentane	5	2	-	2	-	-	-	4	-	6	-	-	-	-	-
3-methylcyclopentane	2	1	-	-	-	-	-	-	-	-	-	-	-	-	4
hexane	15	1	4	-	3	-	-	3	2	-	-	6	-	-	5
methyl cyclopentane	1	4	-	-	3	-	1	2	4	9	5	6	-	-	-
cyclohexane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
unknown	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2,2,4-trimethylpentane	-	3	-	1	-	-	-	-	-	-	-	-	-	-	-
unknown	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
heptane	-	-	6	-	5	-	-	5	5	24	-	10	-	-	-
unknown	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
benzene	-	3	-	-	2	-	-	5	1	-	-	-	-	-	-
unknown	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-
unknown	-	-	-	-	-	-	-	-	-	23	-	9	2	-	1
toluene	4	5	3	3	3	-	-	3	7	6	6	1	-	-	-
unknown	-	-	2	-	-	-	-	-	-	-	-	-	3	1	11
nonane	1	2	-	-	13	2	-	6	18	52	10	54	-	-	-
ethyl benzene	1	-	1	-	-	-	-	1	1	3	-	-	4	1	-
m-xylene&p-xylene	2	1	6	1	2	-	-	1	6	10	1	-	2	-	-
o-xylene	1	1	3	-	-	-	-	-	-	3	-	-	2	-	3
1,3,5 trimethyl benzene	2	4	7	-	2	-	-	4	5	7	4	2	2	-	2
1,2,4 trimethyl benzene	1	3	10	-	-	-	-	-	1	8	-	1	4	-	-
TOTAL	218	98	93	48	108	10	7	82	59	155	57	91	37	6	30

Table 8: Cartridge Analysis Results

DATE Sept. 11, TIME 1530-1630 LOCATION Runway West of Tanks and Sandusk Rd.

Component	Sample Position- concentration (ug/m^3)														
	1	2	3	4	5	6	SAN1	SAN2	SAN3	U1	U2	T1	T2	T3	Blank
ethene&acetylene	1	4	2	1	-	8	7	1	3	5	1				-
propane&propene	-	1	-	-	-	-	-	-	1	-	-				-
isobutane	-	-	-	-	2	-	-	6	-	6	-				-
nbutane,nbutene,2butene	10	-	4	-	6	-	-	4	-	6	3				-
1,3-butadiene	13	11	11	-	-	39	2	-	-	7	-				-
unknown	7	3	-	-	2	-	1	-	1	-	-				-
pentane	121	11	4	-	-	-	-	5	-	-	-				-
unknown	-	-	-	-	-	-	-	-	-	-	-				-
2-methylpentane,cyclopentane	8	12	13	4	7	-	-	-	-	5	-				-
3-methylcyclopentane	2	2	-	-	-	-	-	-	-	-	-				-
hexane	2	6	5	-	-	1	-	1	1	8	-				-
methyl cyclopentane	4	2	-	3	10	1	6	7	3	2	-				4
cyclohexane	-	1	-	-	29	-	-	-	-	-	-				-
unknown	-	-	-	-	27	-	-	-	-	-	-				-
2,2,4-trimethylpentane	4	2	-	3	10	1	6	7		3	2				-
unknown	-	-	-	-	27	-	-	-	-	-	-				-
heptane	1	5	5	-	-	1	-	5	4	4	-				-
unknown	-	-	-	-	-	-	-	-	-	-	-				-
benzene	1	1	2	2	23	32	1	-	2	-	1				-
unknown	1	2	1	-	4	-	-	1	1	1	-				-
unknown	-	2	-	-	11	-	-	-	-	-	-				-
toluene	3	4	3	4	5	47	1	-	3	6	1				-
unknown	-	8	-	-	2	-	-	-	-	-	-				-
nonane	1	2	6	-	21	3	1	-	-	5	3				-
ethyl benzene	-	1	-	2	3	45	-	-	1	-	-				-
m-xylene&p-xylene	-	2	-	5	4	48		-	1	-	-				-
o-xylene	-	2	-	5	4	48	-	-	1	-	-				-
1,3,5 trimethyl benzene	2	4	6	13	14	39	-	-	2	5	8				5
1,2,4 trimethyl benzene	-	5	4	12	15	27	1	-	1	8	5				-
TOTAL	181	93	66	54	226	340	26	37	25	71	24				9

Table 9: Cartridge Analysis Results

DATE Thurs. Sept. 11 **TIME** 1330-1430 **LOCATION** Runway West of Tanks and Sandusk Road

Component	Sample Position- concentration (ug/m^3)														
	1	2	3	4	5	6	SAN 1	SAN 2	SAN3	U1	U2	T1	T2	T3	Blank
ethene&acetylene	1	1	1	1	6	-	1	2	2	-	-				
propane&propene	1	-	-	-	15	21	-	-	2	-	-				
isobutane	-	-	-	-	-	-	-	2	-	-	-				
nbutane,nbutene,2butene	-	-	-	3	95	-	1	-	-	-	-				
1,3-butadiene	1	17	5	-	0	20	-	5	-	-	-				
unknown	1	1	3	-	-	-	-	-	2	-	-				
pentane	2	2	-	-	-	-	14	-	-	-	-				
unknown	-	-	-	-	-	-	-	-	-	-	-				
2-methylpentane,cyclopentane	2	1	1	-	2	-	-	14	-	-	-				
3-methylcyclopentane	-	-	-	-	-	-	-	-	4	-	-				
hexane	1	3	-	-	10	1	3	5	6	17	-				
methyl cyclopentane	22	15	-	-	4	3	8	3	-	-	-				
cyclohexane	-	-	-	-	2	2	-	-	-	-	-				
unknown	-	-	-	-	-	-	-	-	2	-	-				
2,2,4-trimethylpentane	-	-	-	-	-	-	1	-	-	-	-				
unknown	-	-	-	-	-	-	-	-	4	-	-				
heptane	-	2	-	-	22	3	-	28	-	-	-				
unknown	-	-	-	-	-	-	-	-	2	1	2				
benzene	-	-	1	3	1	1	2	-	-	4	-				
unknown	-	-	-	-	-	-	-	1	-	-	-				
unknown	-	1	-	-	25	-	-	4	4	-	-				
toluene	2	4	2	4	4	4	2	2	-	3	-				
unknown	-	-	-	-	-	-	-	5	14	2	-				
nonane	4	2	8	1	50	14	4	20	2	2	-				
ethyl benzene	-	3	-	-	1	1	1	5	1	3	-				
m-xylene&p-xylene	-	6	-	-	3	3	1	15	1	7	-				
o-xylene	1	5	-	-	2	2	1	8	-	12	-				
1,3,5 trimethyl benzene	2	9	-	-	5	9	5	13	5	16	-				
1,2,4 trimethyl benzene	-	7	-	-	6	7	7	22	3	16	-				
TOTAL	40	79	21	12	253	91	51	154	54	83	2				

Table 10: Cartridge Analysis Results

Table 11

10m Winds Sept. 10, 11/1980

TIME	September 10 WIND DIRECTION degrees	WIND SPEED mph	September 11 WIND DIRECTION degrees	WIND SPEED mph
1200	320	11.3	255	21.1
1215	308	11.4	250	20.8
1230	300	11.8	245	19.5
1245	290	11.9	244	19.7
1300	295	11.1	245	20.4
1315	282	12.6	252	20.4
1330	290	11.9	253	19.2
1345	291	10.6	247	17.7
1400	275	12.2	242	16.9
1415	275	11.1	242	18.3
1430	273	12.5	247	17.6
1445	267	12.0	245	17.3
1500	269	14.5	245	18.6
1515	272	15.3	240	18.0
1530	275	12.7	243	17.9
1545	279	13.0	236	17.6
1600	285	13.8	238	17.1
1615	273	15.8	238	17.2
1630	277	15.1	231	17.9
1645	288	14.9	238	17.5
1700	290	12.7	240	17.4
1715	283	14.6	238	16.5
1730	282	14.5	236	15.3
1745	281	12.5	235	15.3

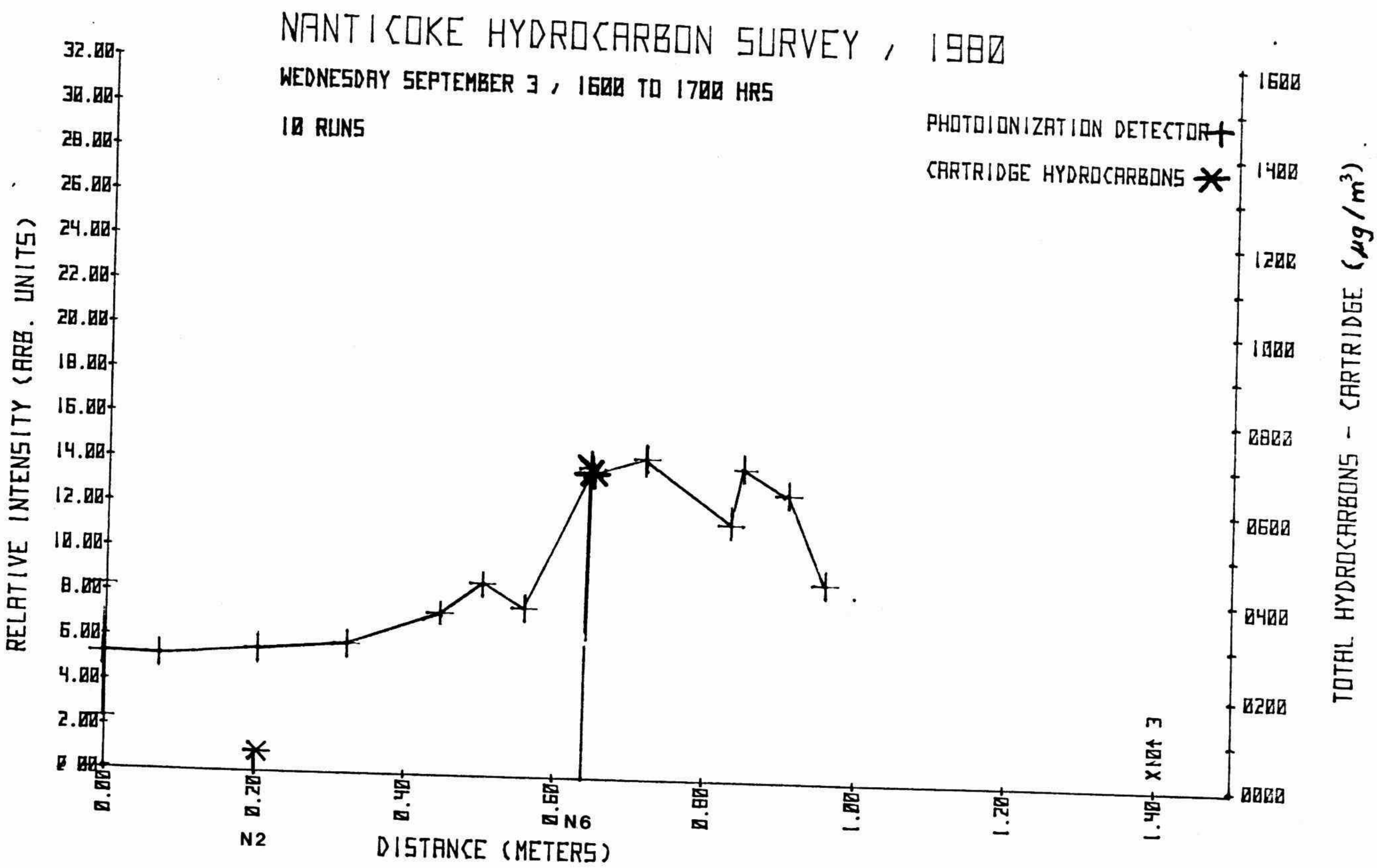

NANTICOKE HYDROCARBON SURVEY , 1980
WEDNESDAY SEPTEMBER 3 , 1600 TO 1700 HRS
10 RUNS
PHOTOIONIZATION DETECTOR
CARTRIDGE HYDROCARBONS
RELATIVE INTENSITY (ARB. UNITS)
TOTAL HYDROCARBONS - CARTRIDGE ($\mu g/m^3$)
DISTANCE (METERS)
N2
N6
X10↑ 3

Fig. 1

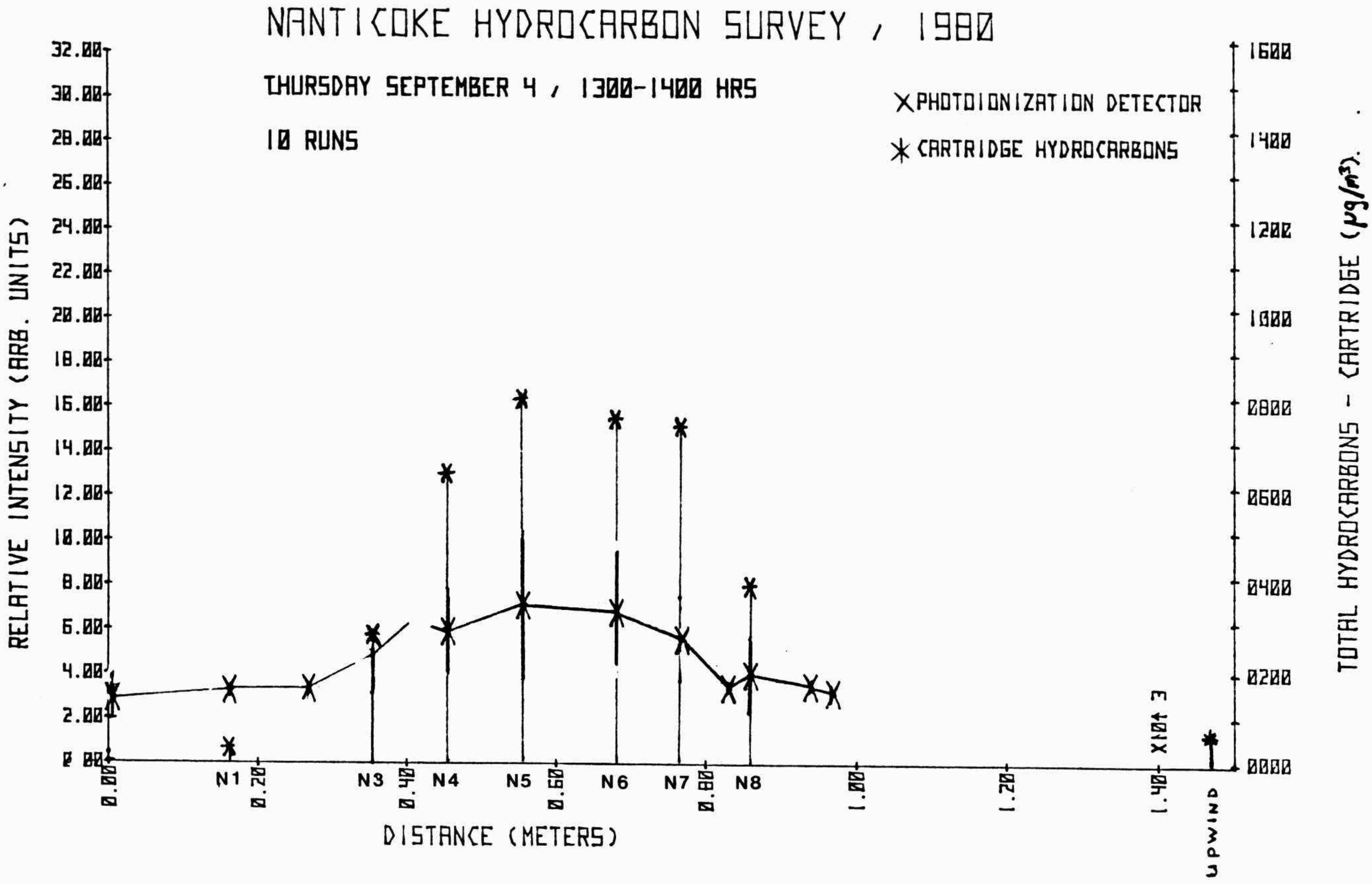

NANTICOKE HYDROCARBON SURVEY , 1980
THURSDAY SEPTEMBER 4 , 1300-1400 HRS
10 RUNS
X PHOTOIONIZATION DETECTOR
* CARTRIDGE HYDROCARBONS
RELATIVE INTENSITY (ARB. UNITS)
32.00
30.00
28.00
26.00
24.00
22.00
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
TOTAL HYDROCARBONS - CARTRIDGE (μg/m³)
1600
1400
1200
1000
0800
0600
0400
0200
0000
N1
N3
N4
N5
N6
N7
N8
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
X10↑ 3
UPWIND
DISTANCE (METERS)

Fig. 2

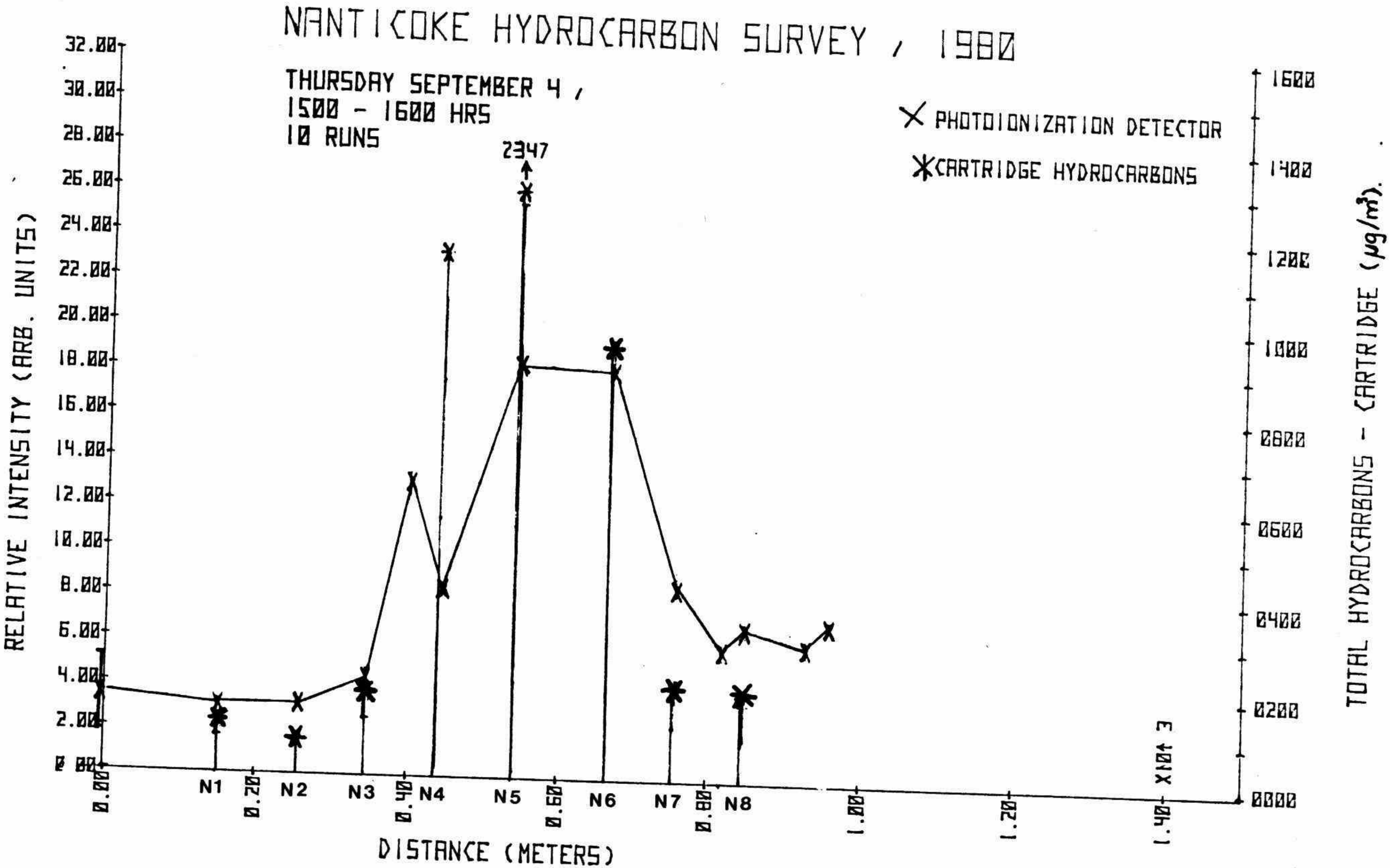

NANTICOKE HYDROCARBON SURVEY , 1980
THURSDAY SEPTEMBER 4 ,
1500 - 1600 HRS
10 RUNS
PHOTOIONIZATION DETECTOR
CARTRIDGE HYDROCARBONS
2347
RELATIVE INTENSITY (ARB. UNITS)
TOTAL HYDROCARBONS - CARTRIDGE (µg/m³)
DISTANCE (METERS)
X10↑ 3
N1
N2
N3
N4
N5
N6
N7
N8

Fig. 3

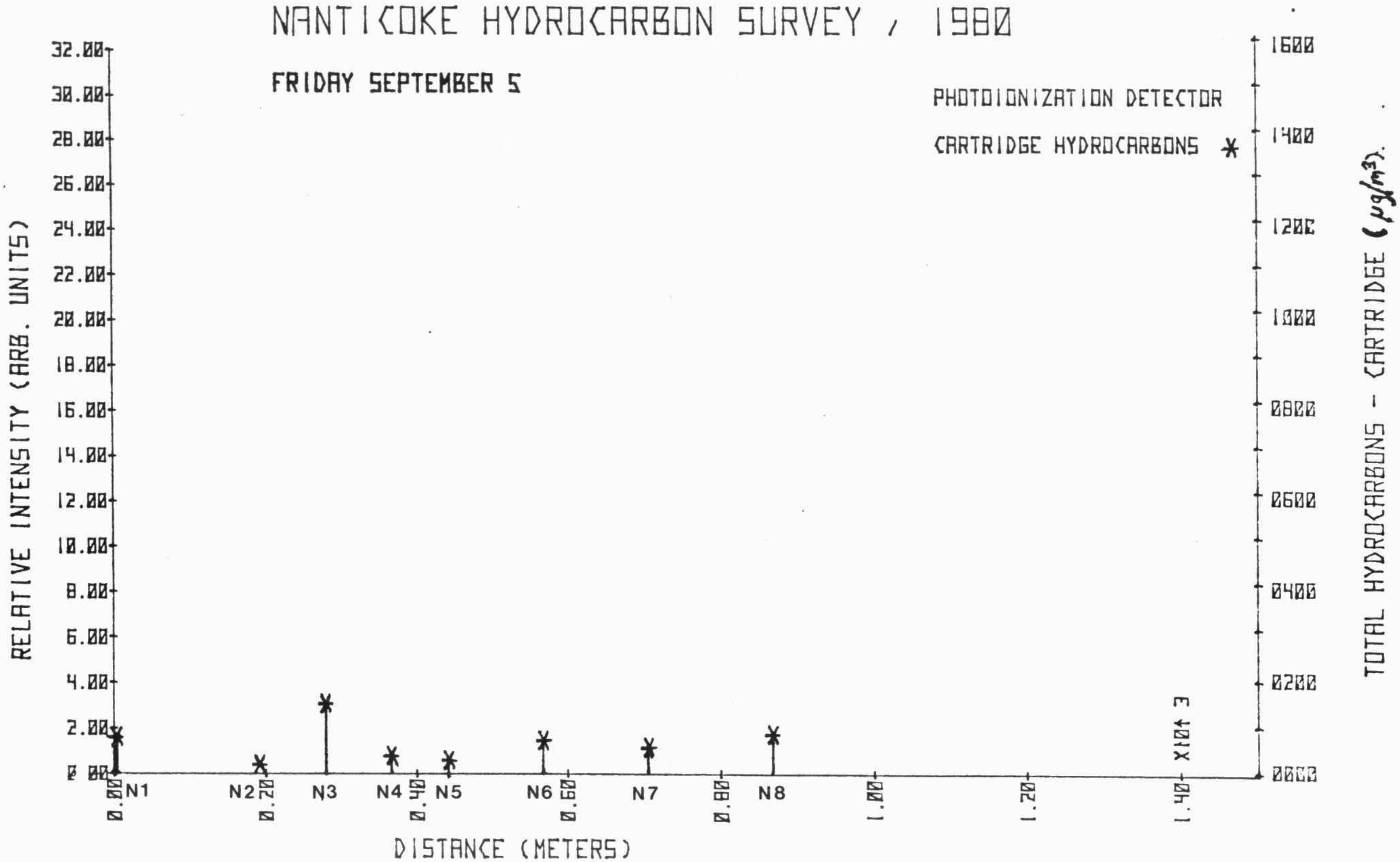

NANTICOKE HYDROCARBON SURVEY , 1980
FRIDAY SEPTEMBER 5
PHOTOIONIZATION DETECTOR
CARTRIDGE HYDROCARBONS *
RELATIVE INTENSITY (ARB. UNITS)
TOTAL HYDROCARBONS - CARTRIDGE (μg/m³)
DISTANCE (METERS)
X10↑ 3
N1
N2
N3
N4
N5
N6
N7
N8
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
26.00
28.00
30.00
32.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
0000
0200
0400
0600
0800
1000
1200
1400
1600

Fig. 4

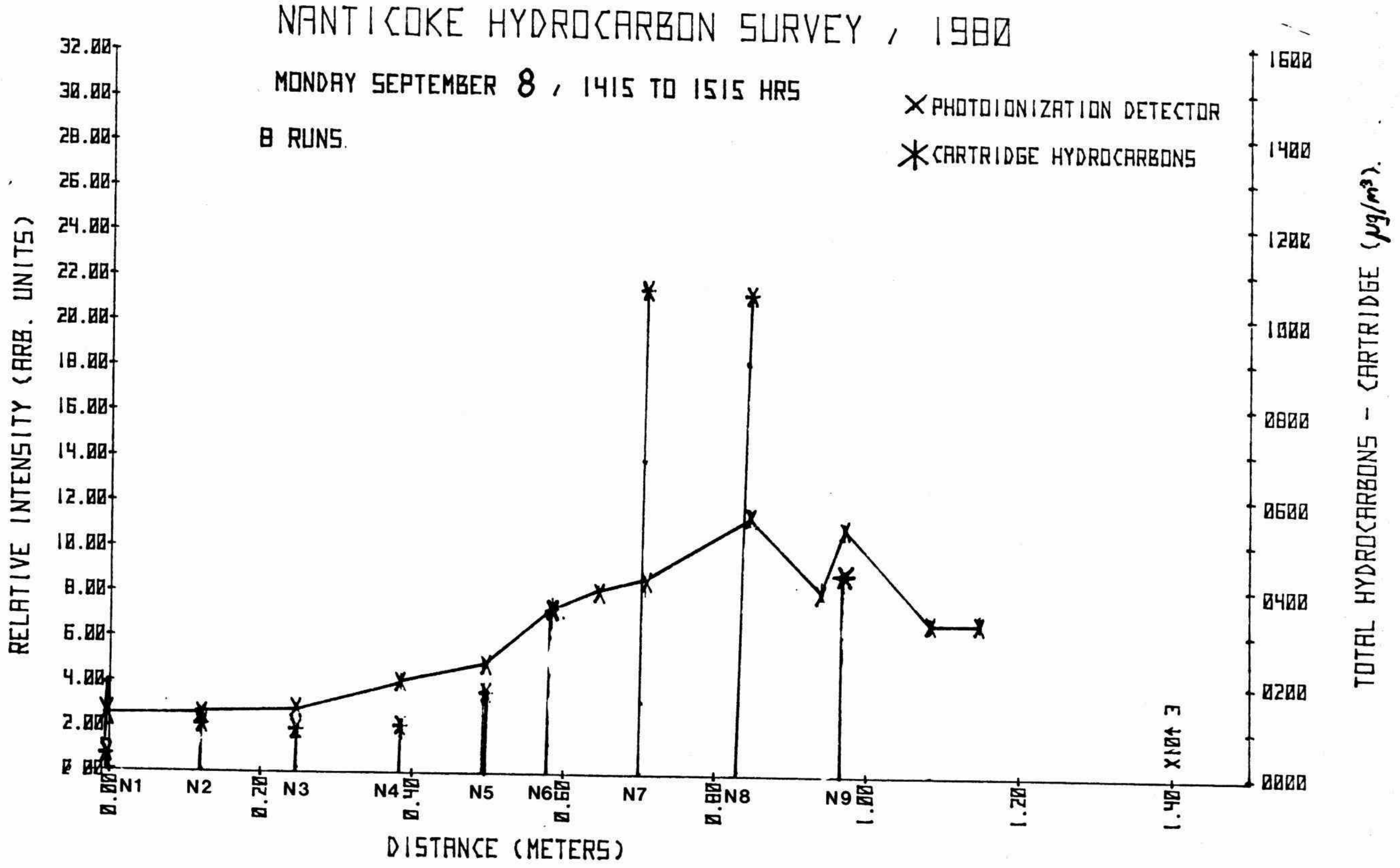

NANTICOKE HYDROCARBON SURVEY , 1980
MONDAY SEPTEMBER 8 , 1415 TO 1515 HRS
8 RUNS
X PHOTOIONIZATION DETECTOR
✱ CARTRIDGE HYDROCARBONS
RELATIVE INTENSITY (ARB. UNITS)
TOTAL HYDROCARBONS - CARTRIDGE (µg/m³).
DISTANCE (METERS)
X10↑ 3
N1
N2
N3
N4
N5
N6
N7
N8
N9

Fig. 5

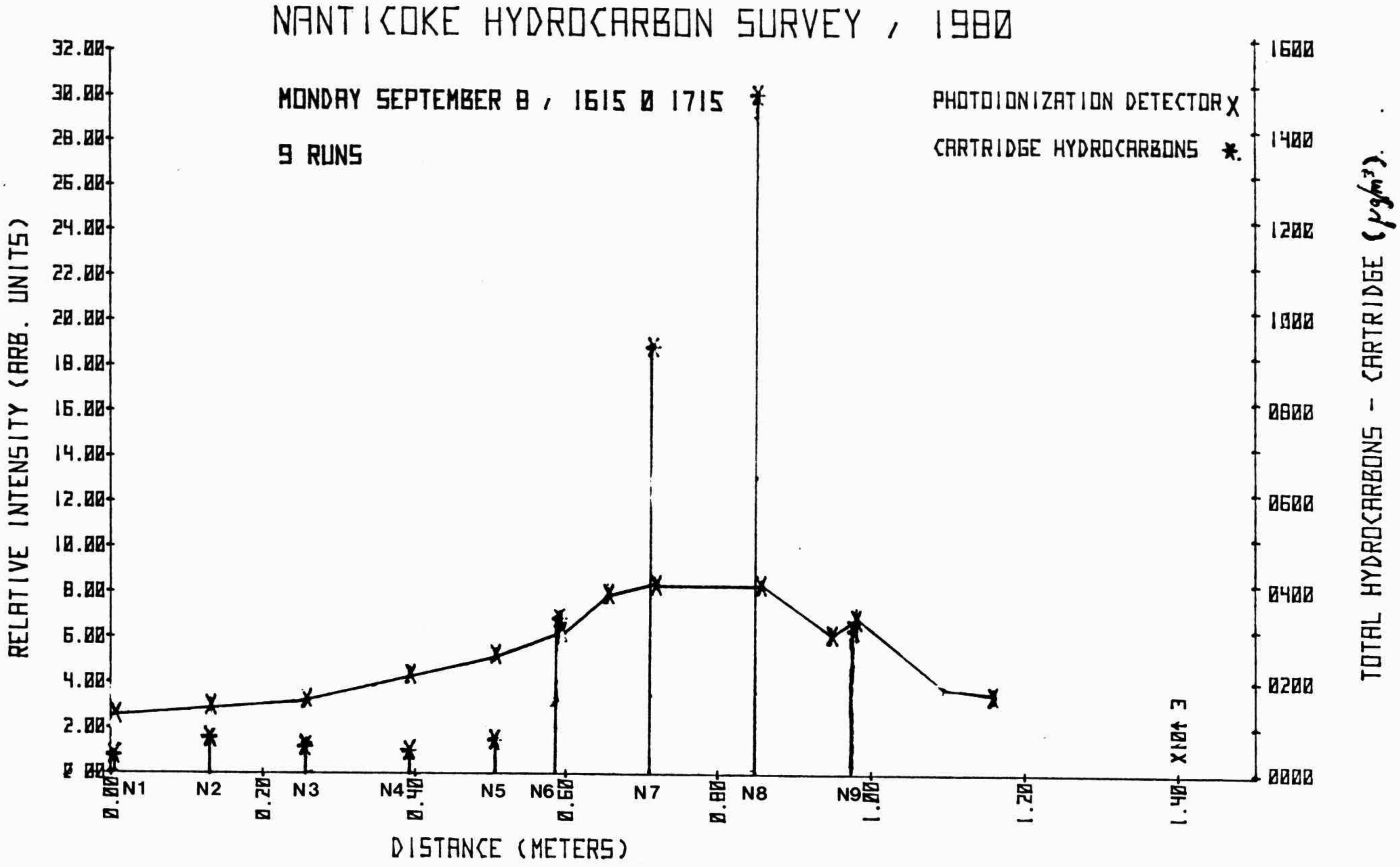

NANTICOKE HYDROCARBON SURVEY / 1980
MONDAY SEPTEMBER 8 / 1615 Ø 1715
9 RUNS
PHOTOIONIZATION DETECTOR X
CARTRIDGE HYDROCARBONS *
RELATIVE INTENSITY (ARB. UNITS)
TOTAL HYDROCARBONS - CARTRIDGE (μg/m³)
DISTANCE (METERS)
32.ØØ
30.ØØ
28.ØØ
26.ØØ
24.ØØ
22.ØØ
20.ØØ
18.ØØ
16.ØØ
14.ØØ
12.ØØ
10.ØØ
8.ØØ
6.ØØ
4.ØØ
2.ØØ
Ø.ØØ
1600
1400
1200
1000
Ø800
Ø600
Ø400
Ø200
ØØØØ
Ø.ØØ
Ø.20
Ø.40
Ø.60
Ø.80
1.ØØ
1.20
1.40
X1Ø↑ 3
N1
N2
N3
N4
N5
N6
N7
N8
N9

Fig. 6

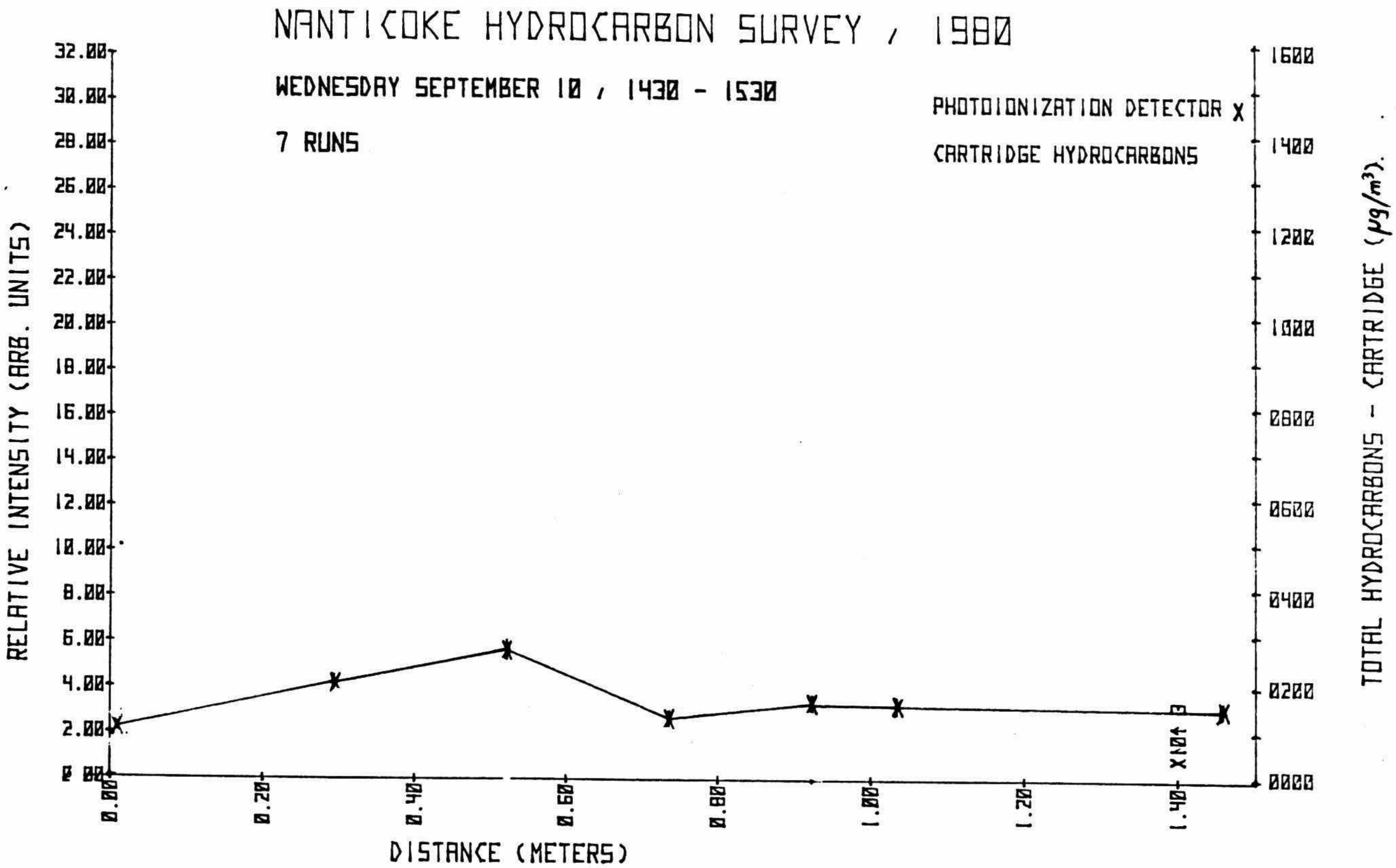

NANTICOKE HYDROCARBON SURVEY / 1980
WEDNESDAY SEPTEMBER 10 / 1430 - 1530
7 RUNS
PHOTOIONIZATION DETECTOR X
CARTRIDGE HYDROCARBONS
RELATIVE INTENSITY (ARB. UNITS)
TOTAL HYDROCARBONS - CARTRIDGE (μg/m³)
DISTANCE (METERS)
32.00
30.00
28.00
26.00
24.00
22.00
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1600
1400
1200
1000
0800
0600
0400
0200
0000
X10↑3

Fig. 7

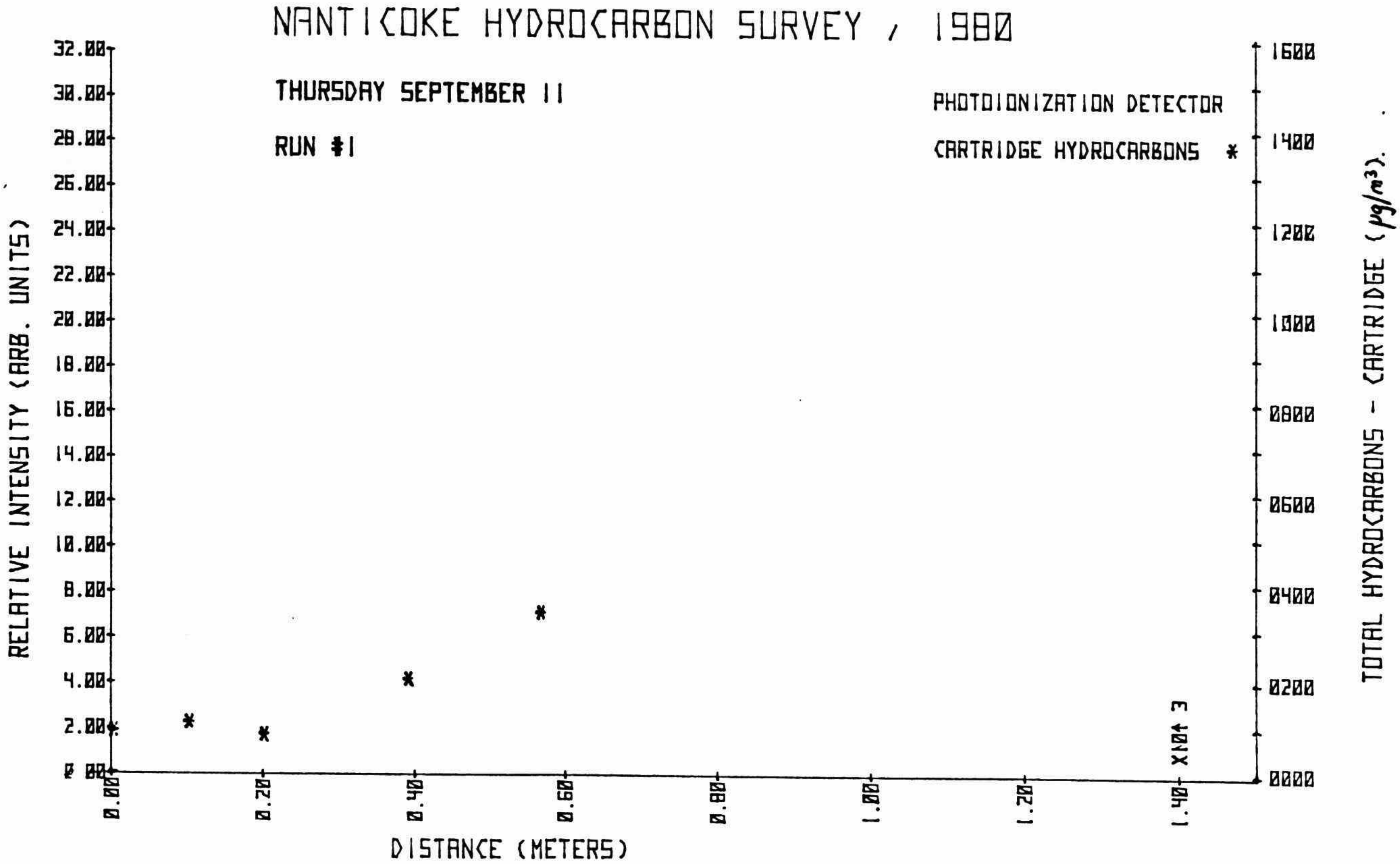

NANTICOKE HYDROCARBON SURVEY , 1980
THURSDAY SEPTEMBER 11
RUN #1
PHOTOIONIZATION DETECTOR
CARTRIDGE HYDROCARBONS *
RELATIVE INTENSITY (ARB. UNITS)
TOTAL HYDROCARBONS - CARTRIDGE (μg/m³).
DISTANCE (METERS)
32.00
30.00
28.00
26.00
24.00
22.00
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
1600
1400
1200
1000
0800
0600
0400
0200
0000
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
X10↑ 3

Fig. 8

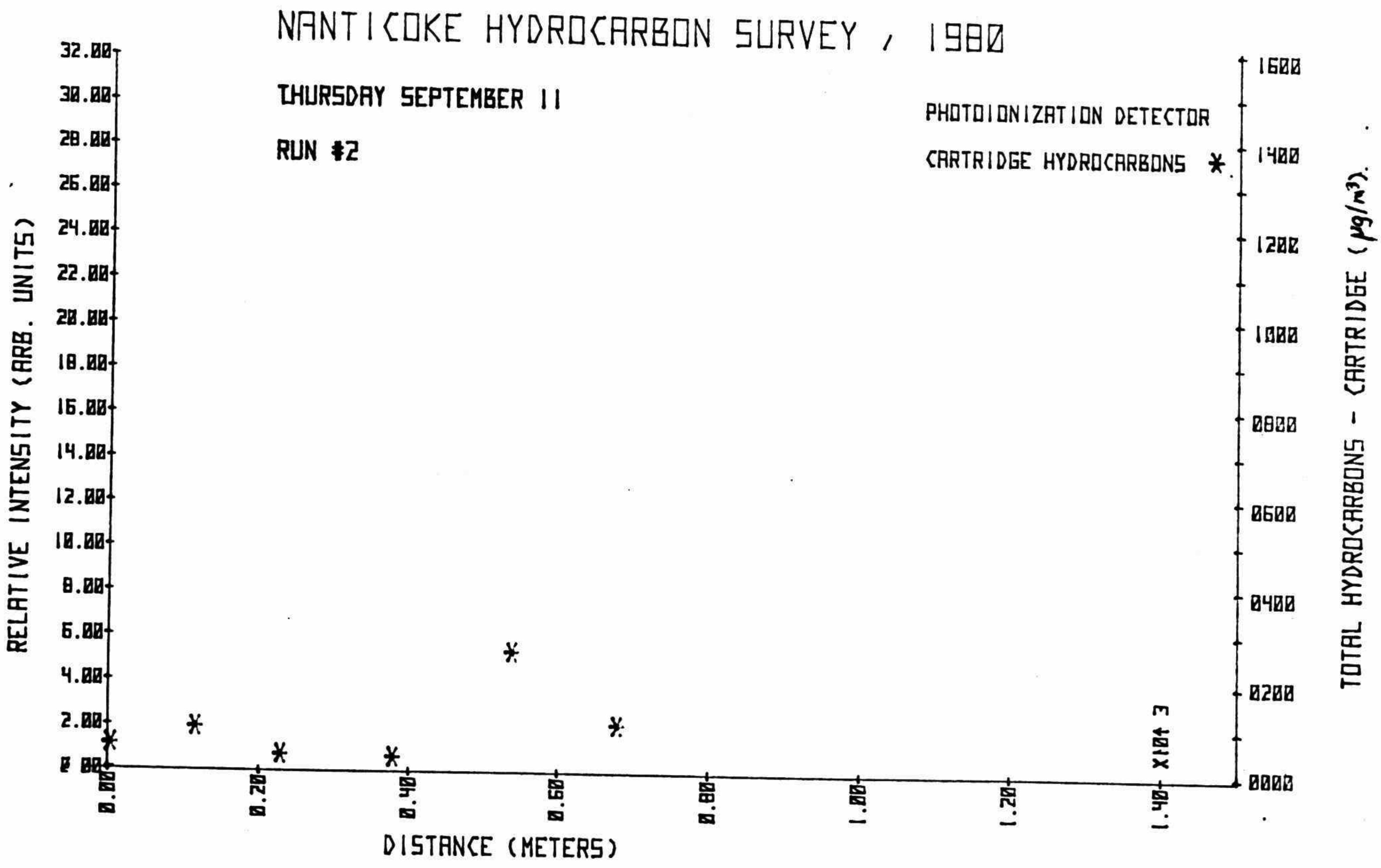
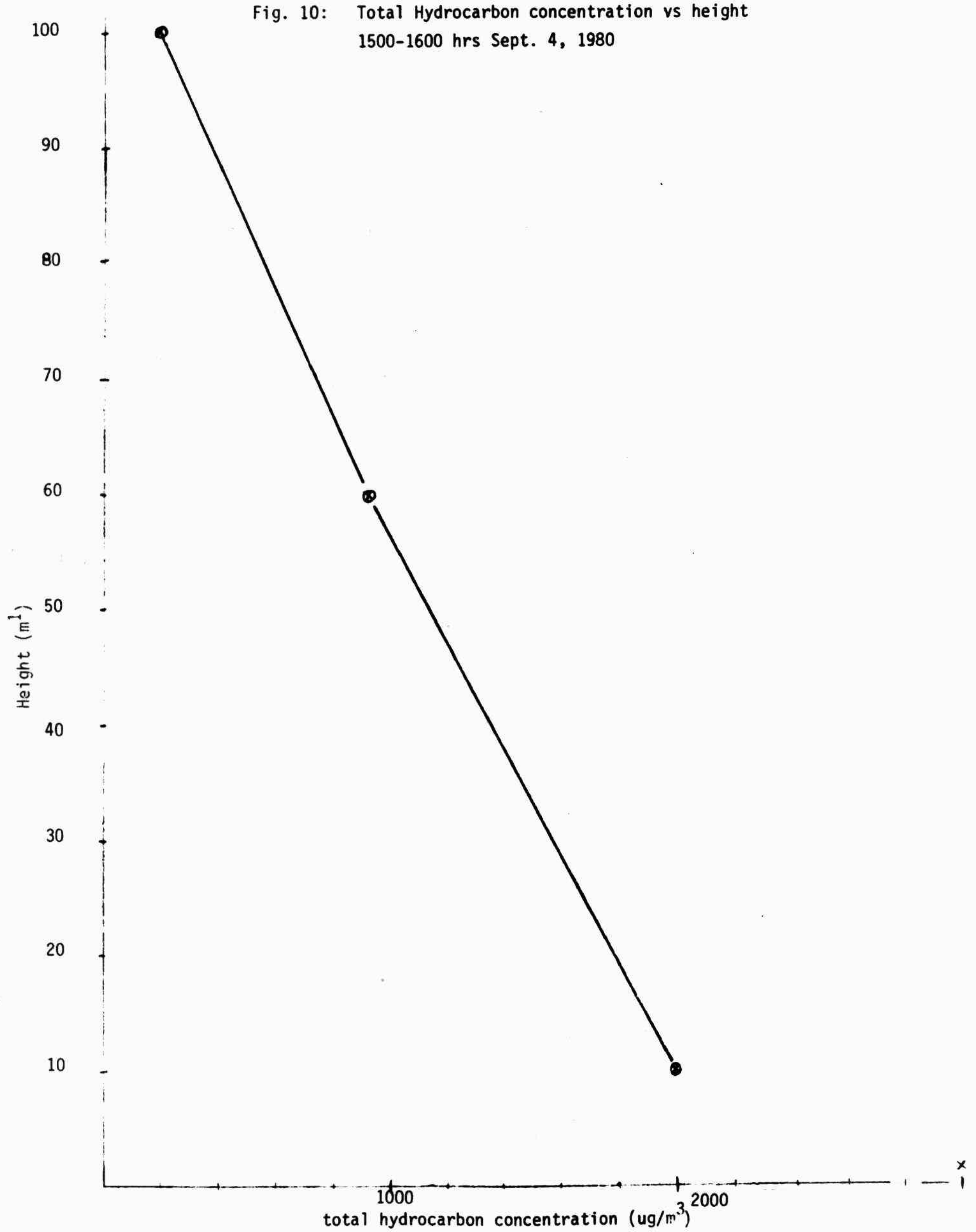

NANTICOKE HYDROCARBON SURVEY / 1980
THURSDAY SEPTEMBER 11
RUN #2
PHOTOIONIZATION DETECTOR
CARTRIDGE HYDROCARBONS *
RELATIVE INTENSITY (ARB. UNITS)
TOTAL HYDROCARBONS - CARTRIDGE (μg/m³)
DISTANCE (METERS)
X10↑ 3
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
26.00
28.00
30.00
32.00
0000
0200
0400
0600
0800
1000
1200
1400
1600
0.20
0.40
0.60
0.80
1.00
1.20
1.40

Fig. 9

Fig. 10: Total Hydrocarbon concentration vs height
1500-1600 hrs Sept. 4, 1980



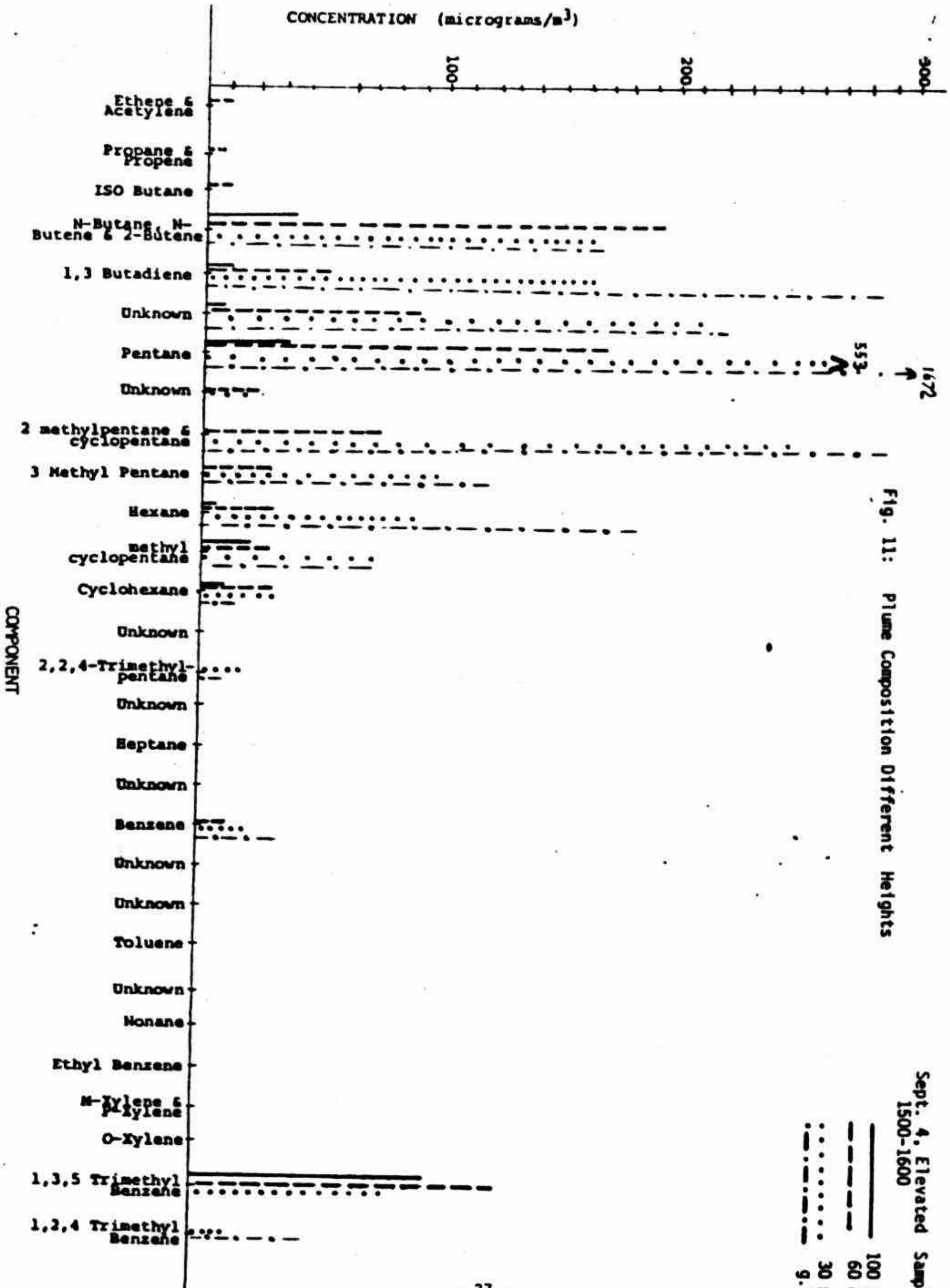
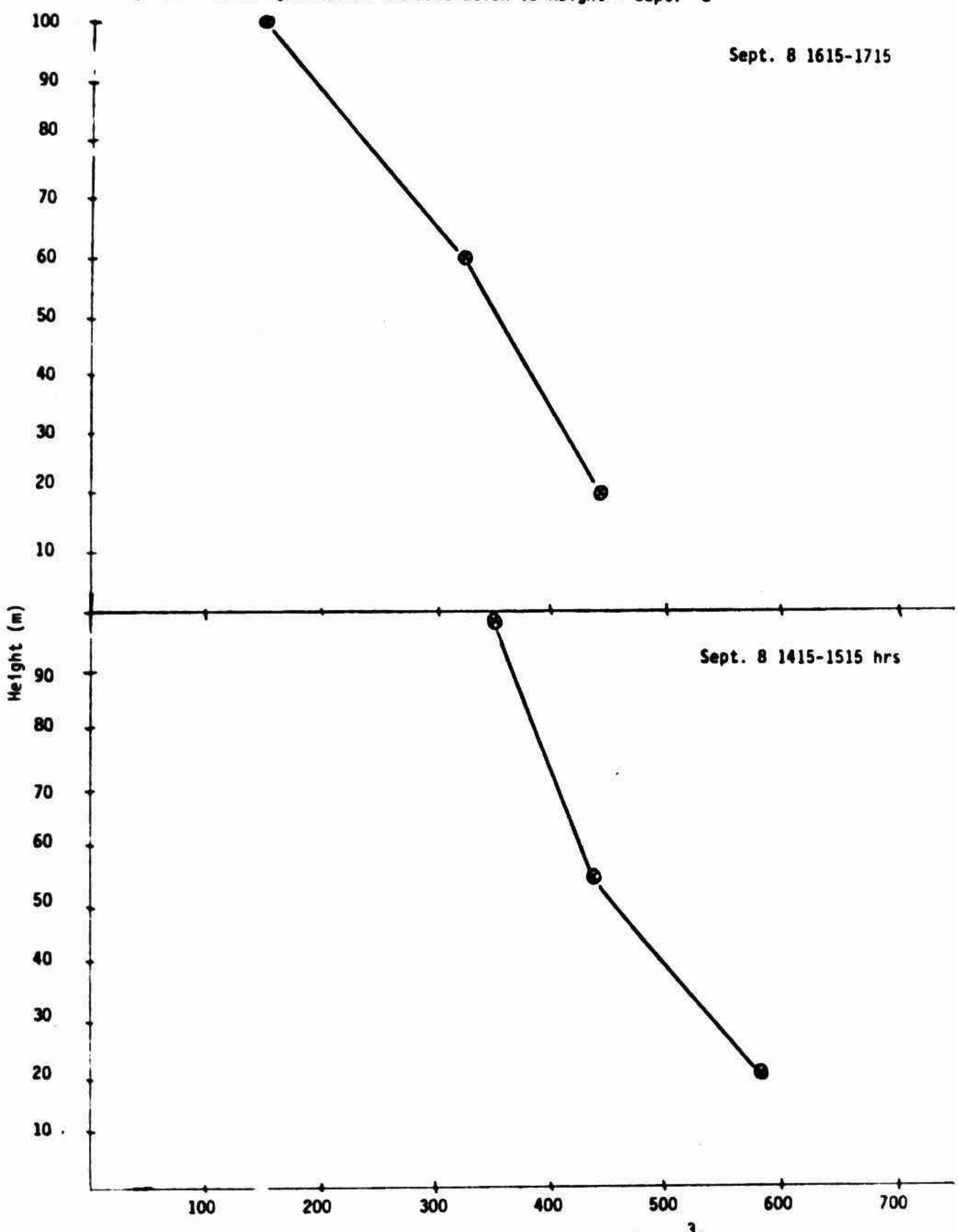


Fig. 11: Plume Composition Different Heights

Fig. 11: Total Hydrocarbon Concentration vs Height - Sept. 8



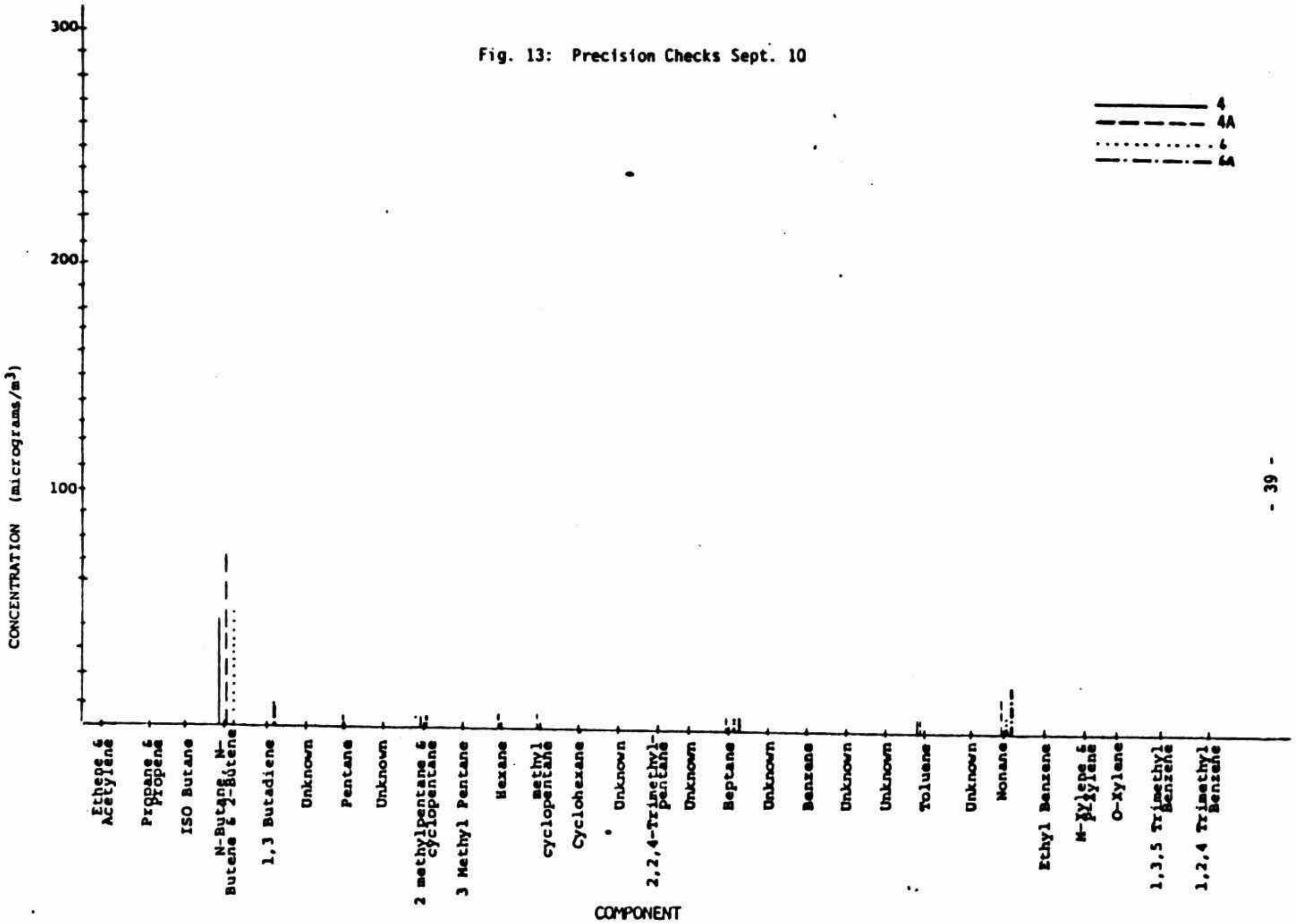
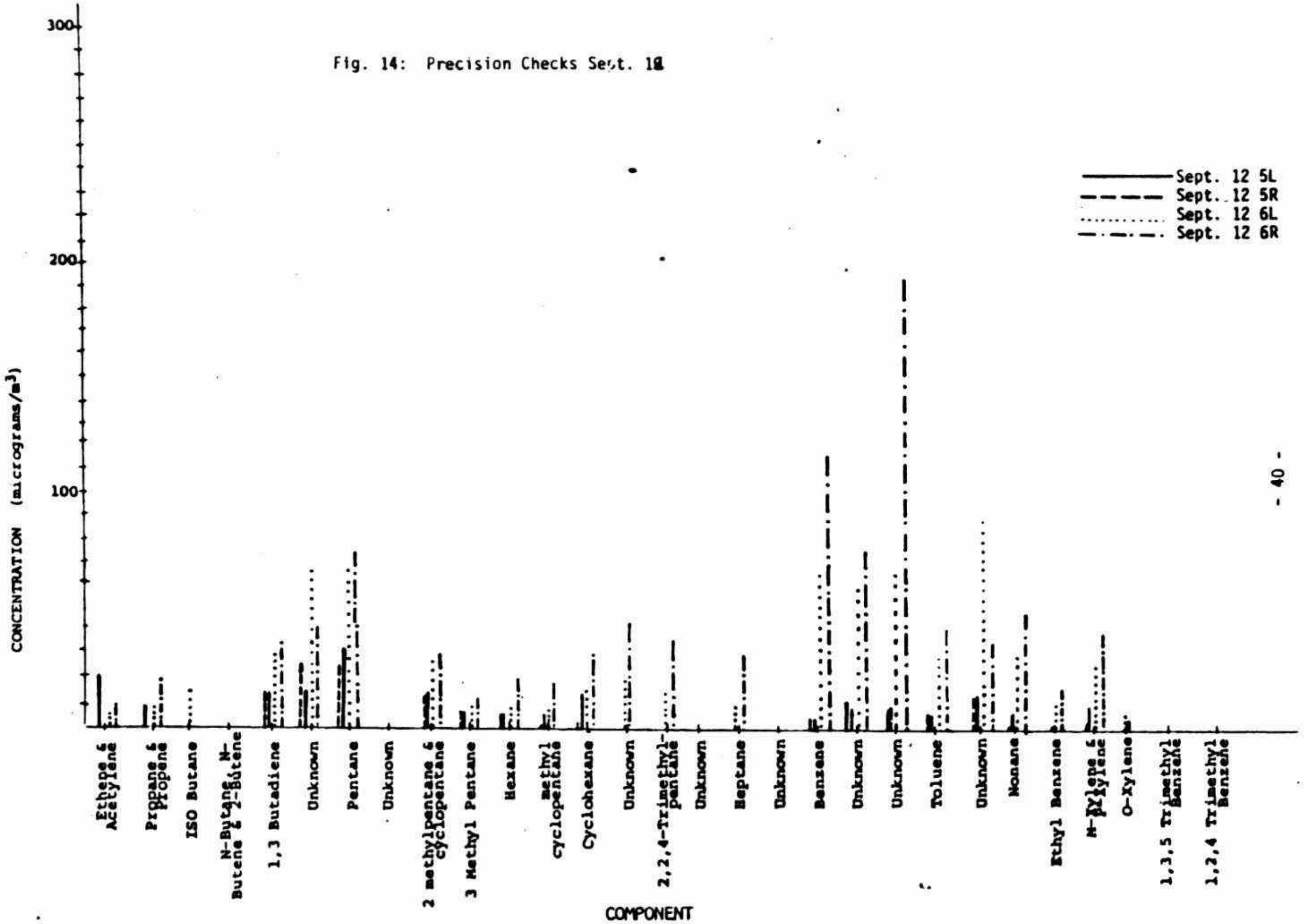
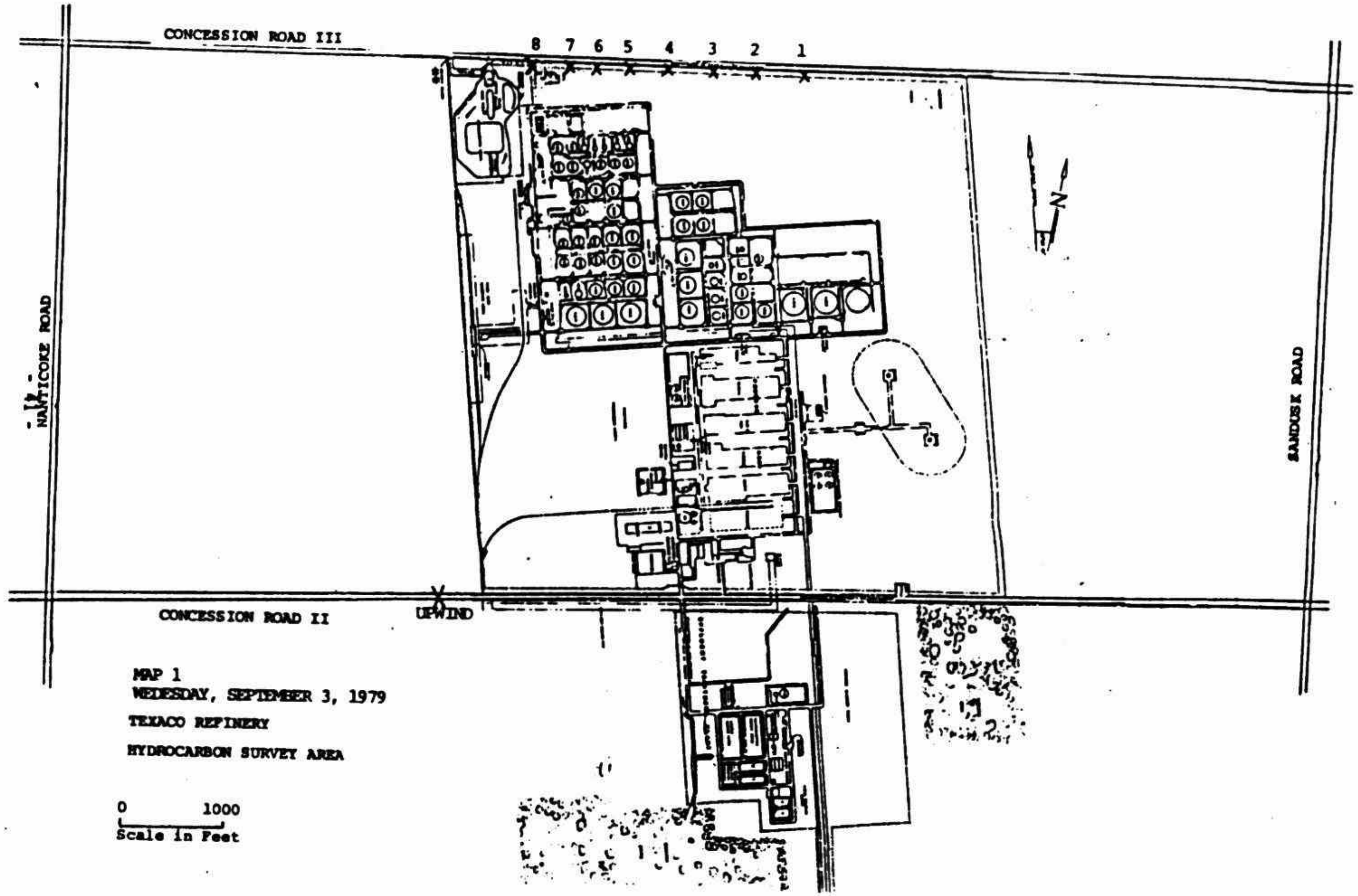


Fig. 13: Precision Checks Sept. 10

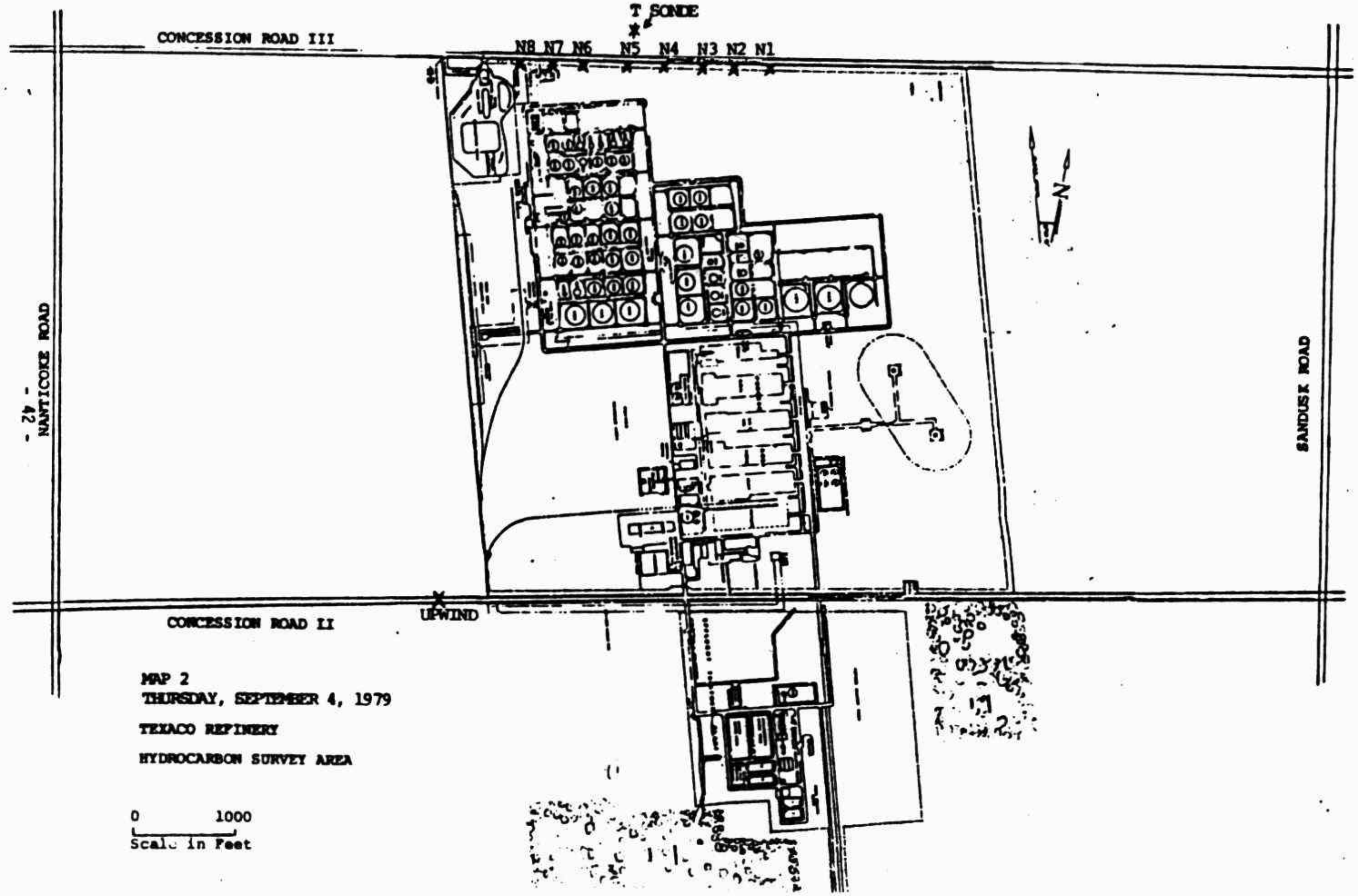
Fig. 14: Precision Checks Sept. 12



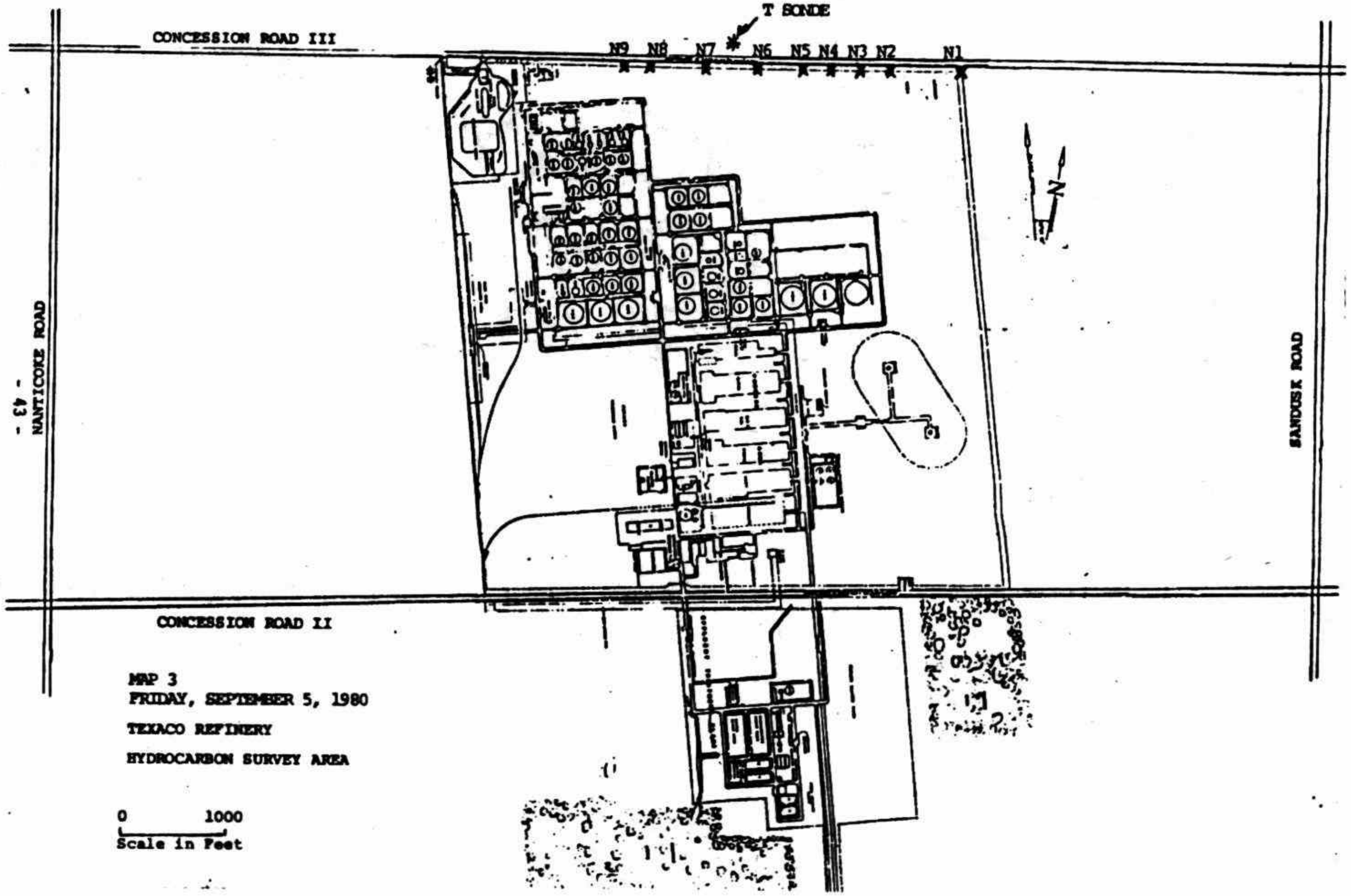


MAP 1
WEDESDAY, SEPTEMBER 3, 1979
TEXACO REFINERY
HYDROCARBON SURVEY AREA

0 1000
Scale in Feet



MAP 2
THURSDAY, SEPTEMBER 4, 1979
TEXACO REFINERY
HYDROCARBON SURVEY AREA

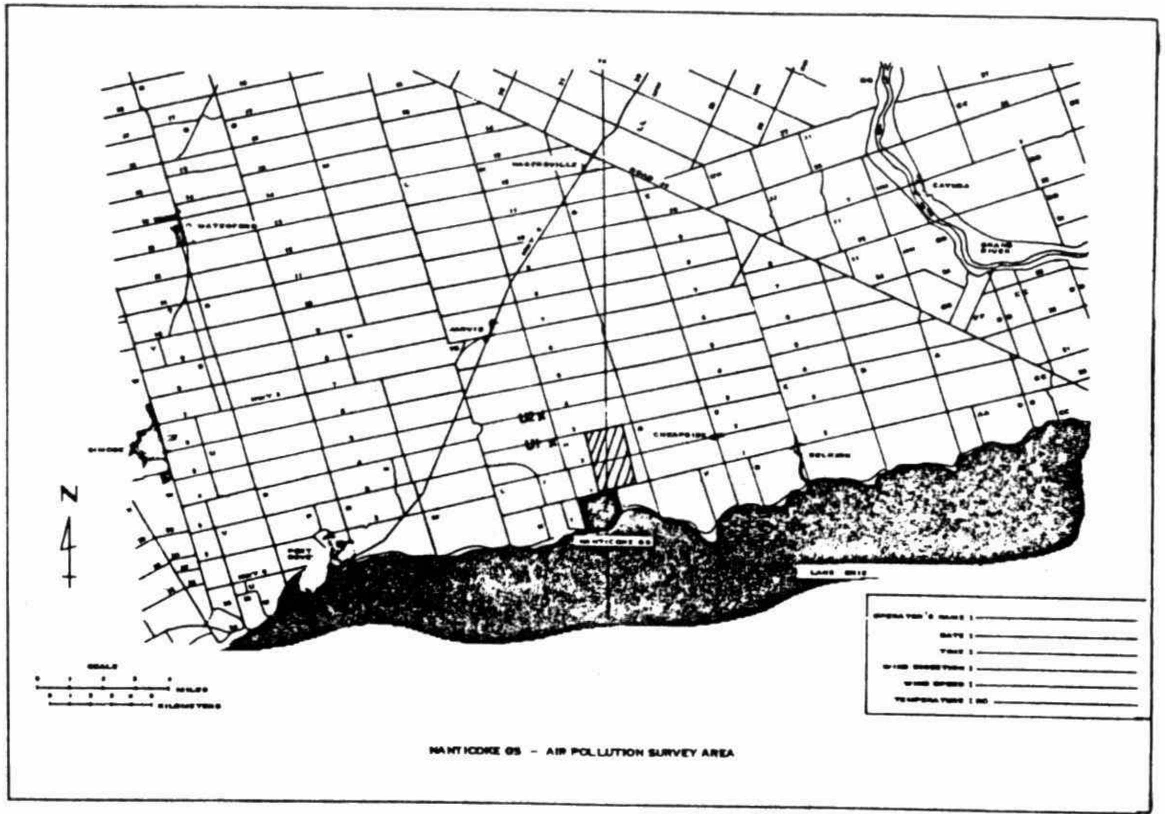


MAP 3
FRIDAY, SEPTEMBER 5, 1980

TEXACO REFINERY

HYDROCARBON SURVEY AREA

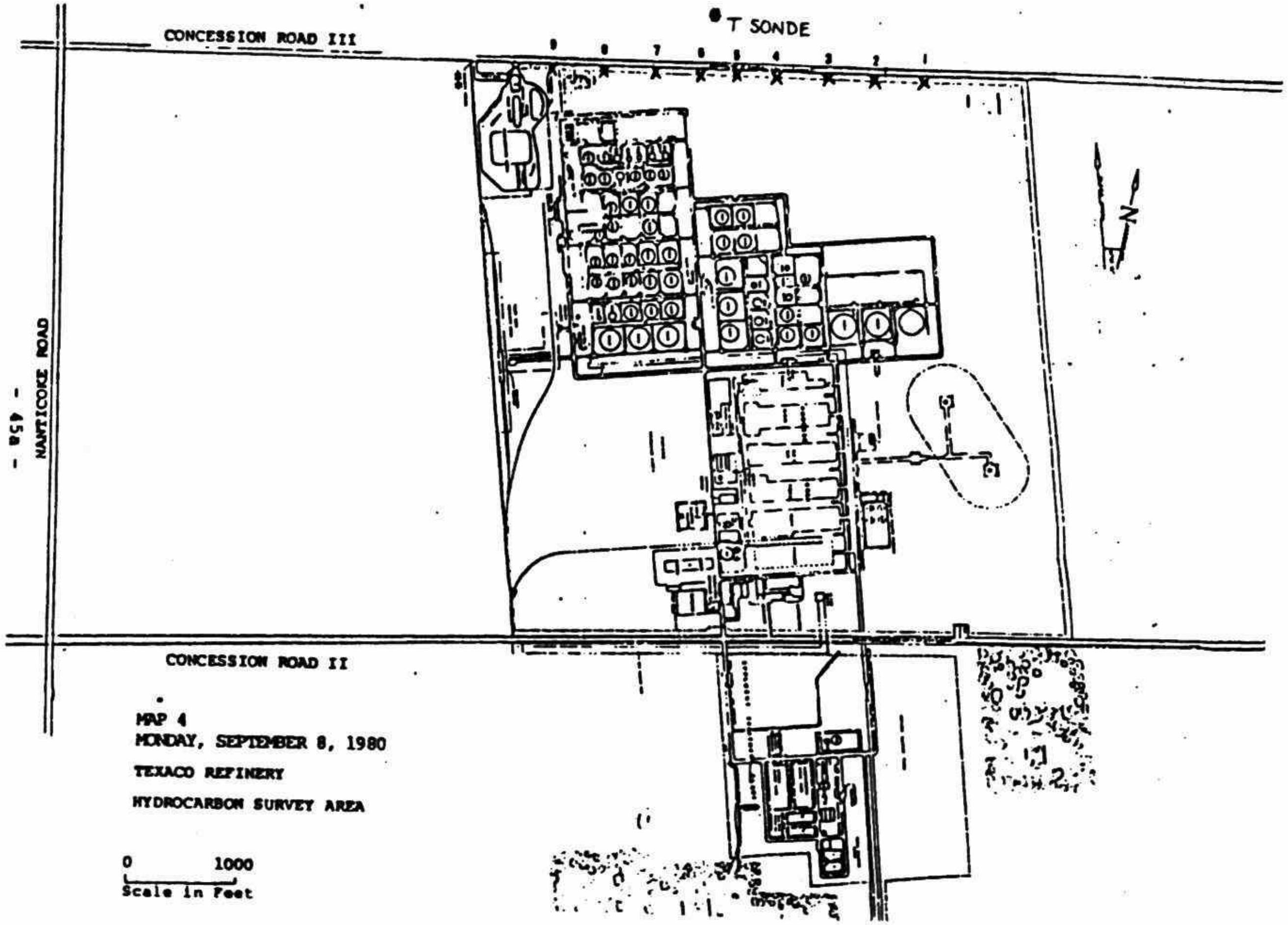
0 1000
Scale in Feet



MAP 3A

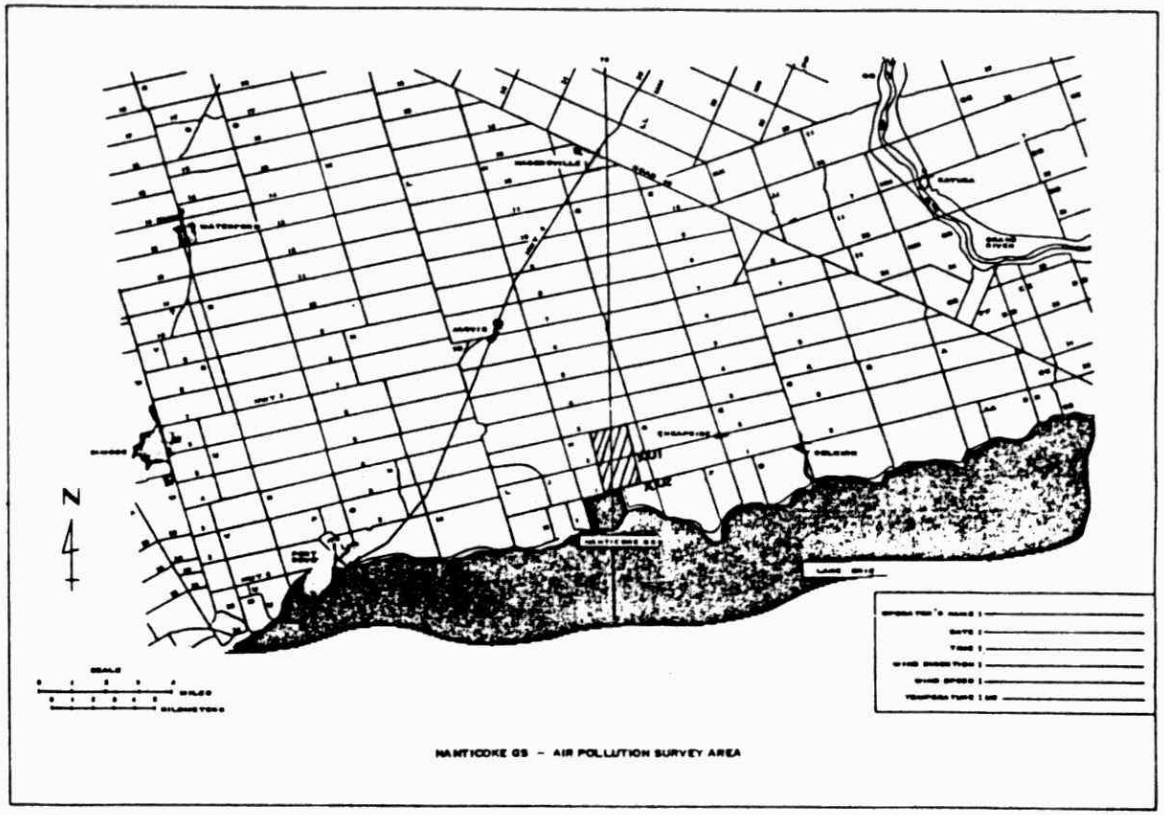
FRIDAY, SEPTEMBER 5, 1980

UPWIND SAMPLER LOCATIONS



T SONDE
CONCESSION ROAD III
9 8 7 6 5 4 3 2 1
N
NANTICOKE ROAD
CONCESSION ROAD II
MAP 4
MONDAY, SEPTEMBER 8, 1980
TEXACO REFINERY
HYDROCARBON SURVEY AREA
0 1000
Scale in Feet

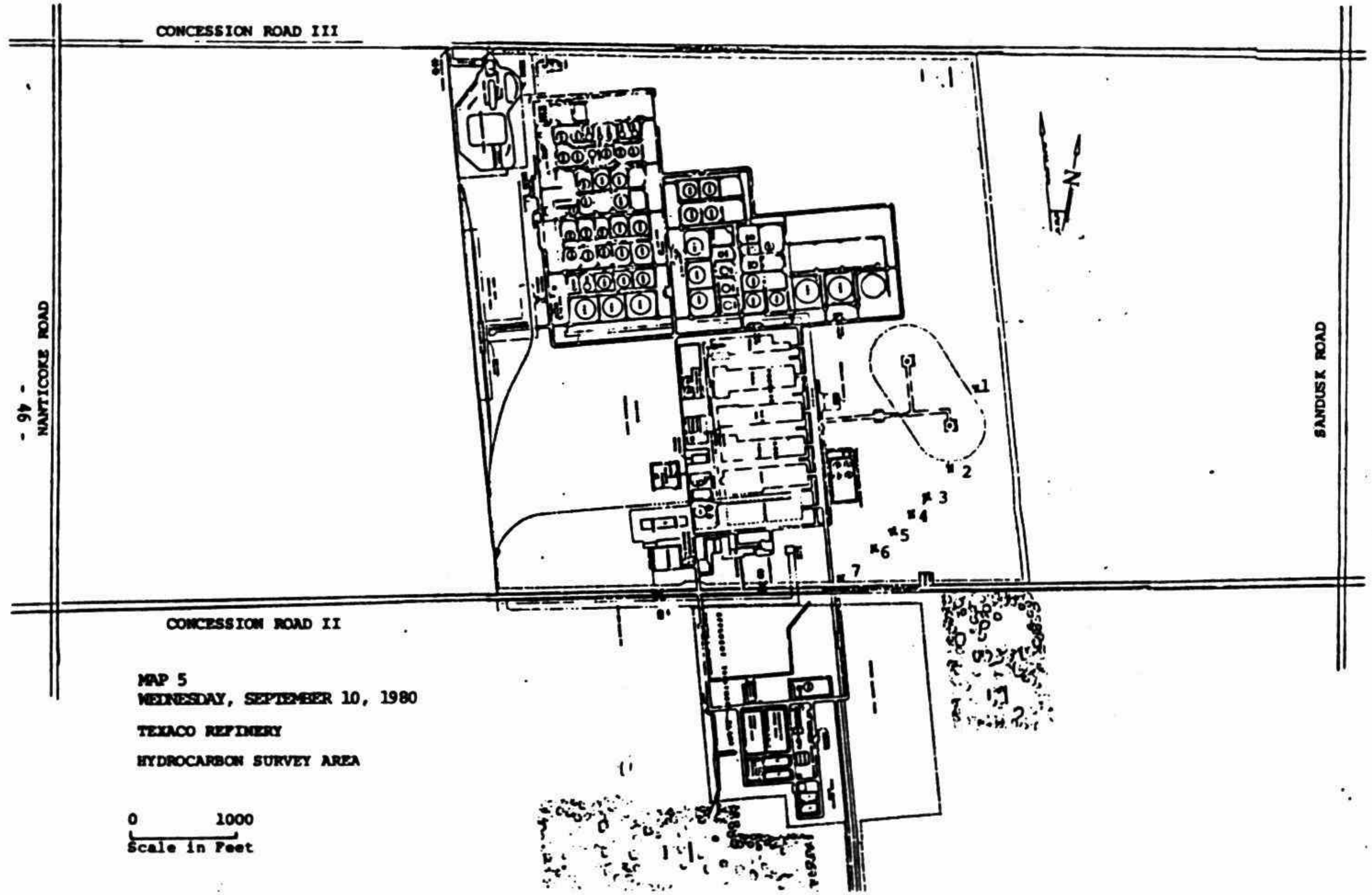
- 45a -



MAP 4A

MONDAY, SEPTEMBER 8, 1980

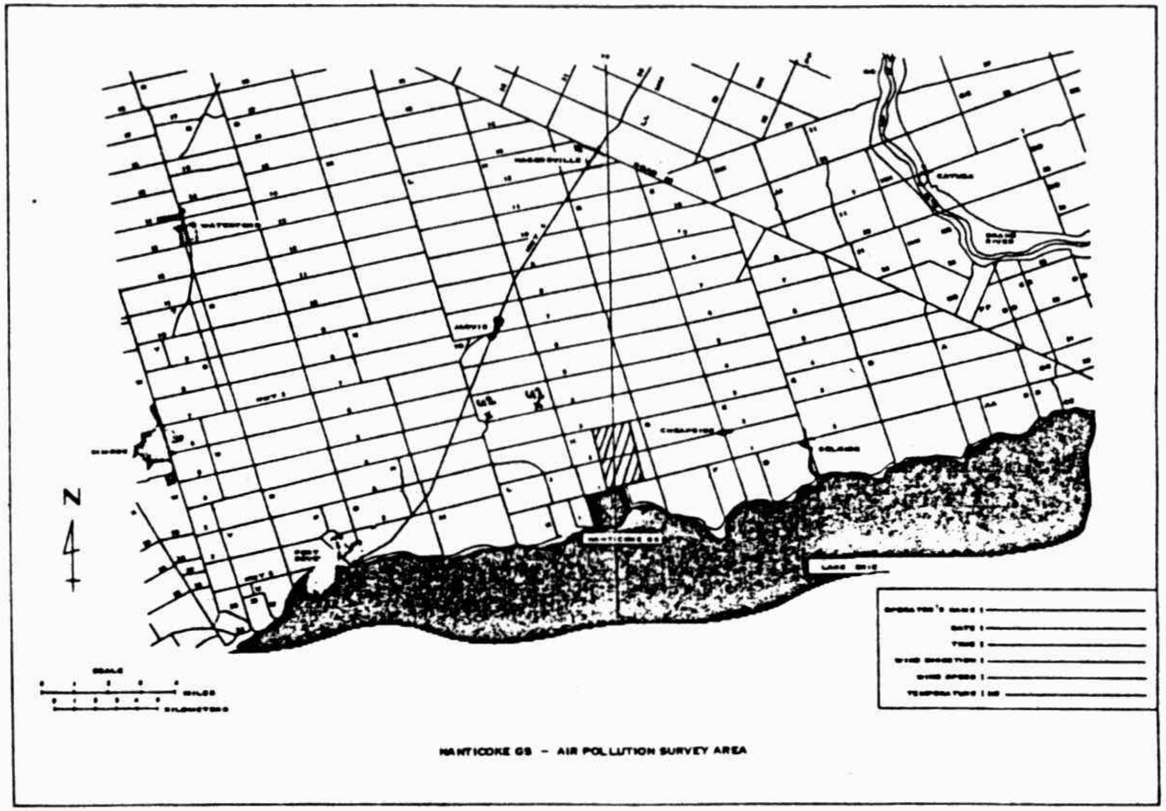
UPWIND SAMPLE LOCATIONS



MAP 5
WEDNESDAY, SEPTEMBER 10, 1980

TEXACO REFINERY

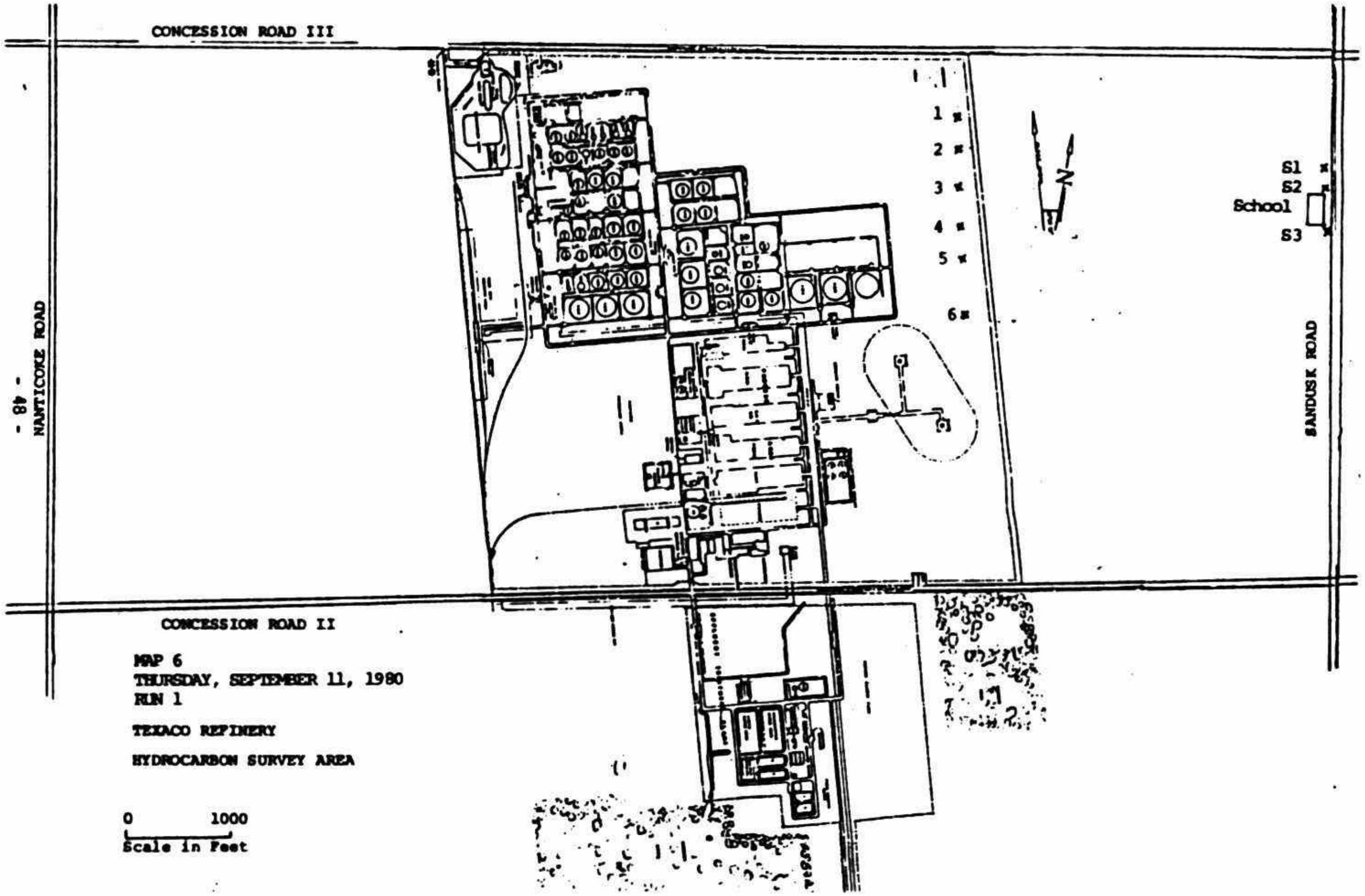
HYDROCARBON SURVEY AREA



MAP 5A

WEDNESDAY, SEPTEMBER 10, 1980

UPWIND SAMPLING LOCATIONS

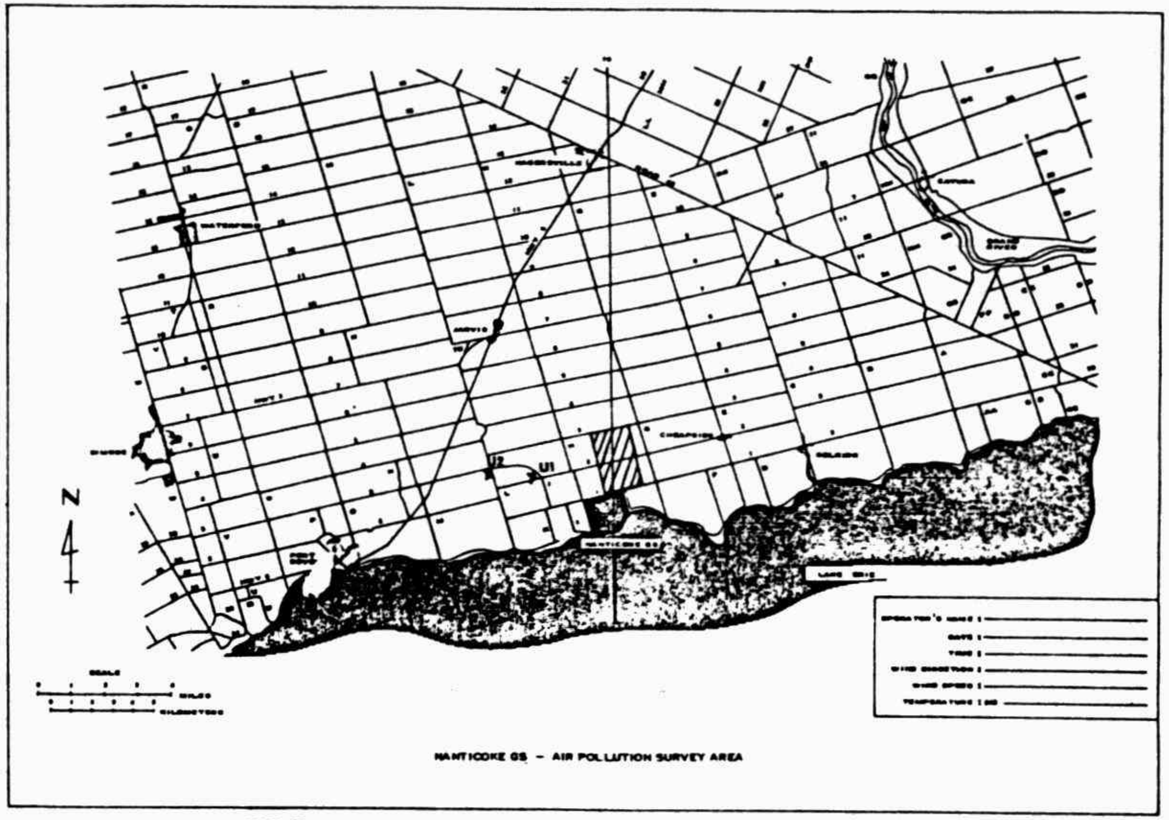


MAP 6
THURSDAY, SEPTEMBER 11, 1980
RUN 1

TEXACO REFINERY

HYDROCARBON SURVEY AREA

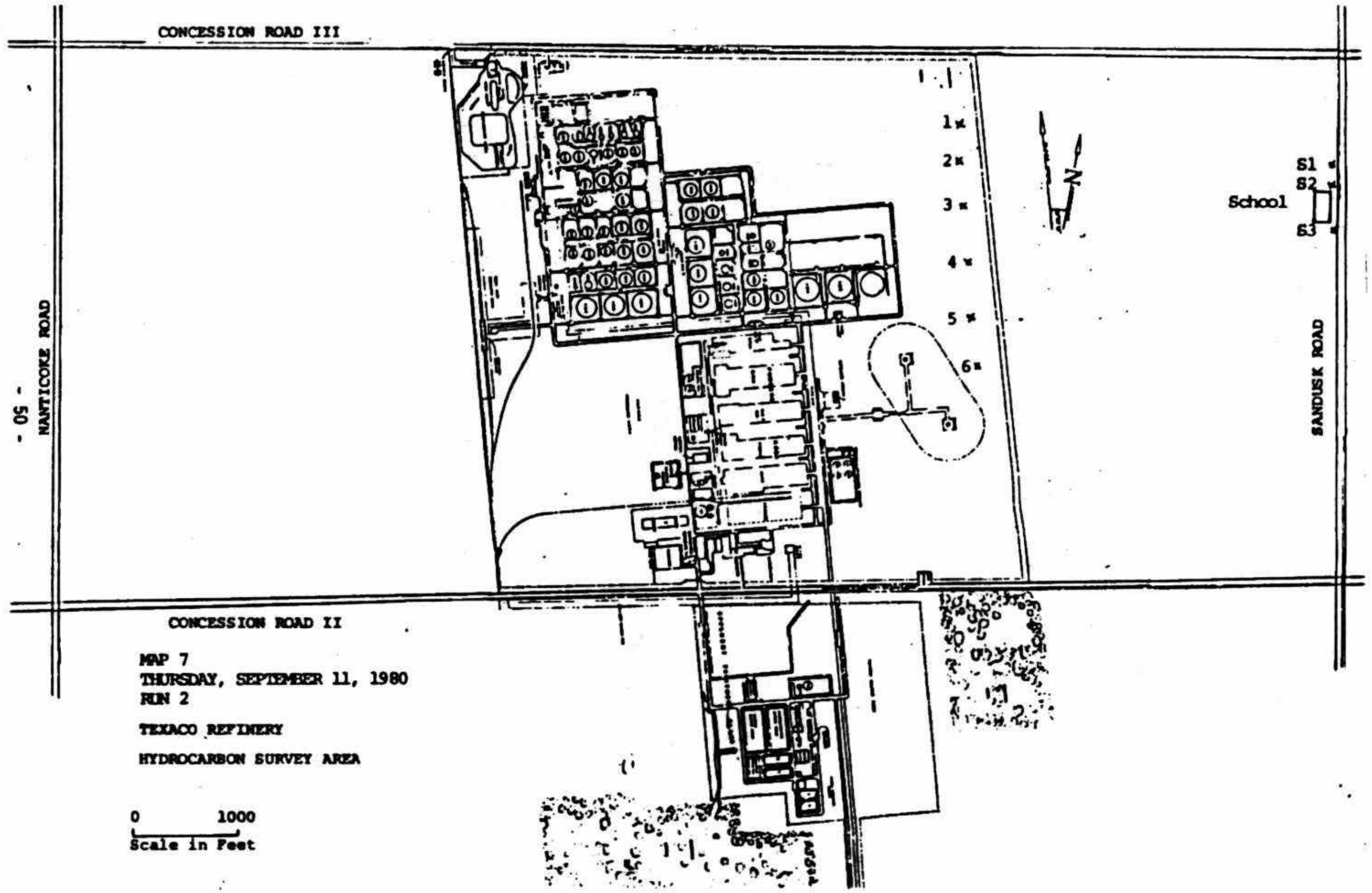
0 1000
Scale in Feet



MAP 6A

THURSDAY, SEPTEMBER 11, 1980

UPWIND SAMPLING LOCATIONS

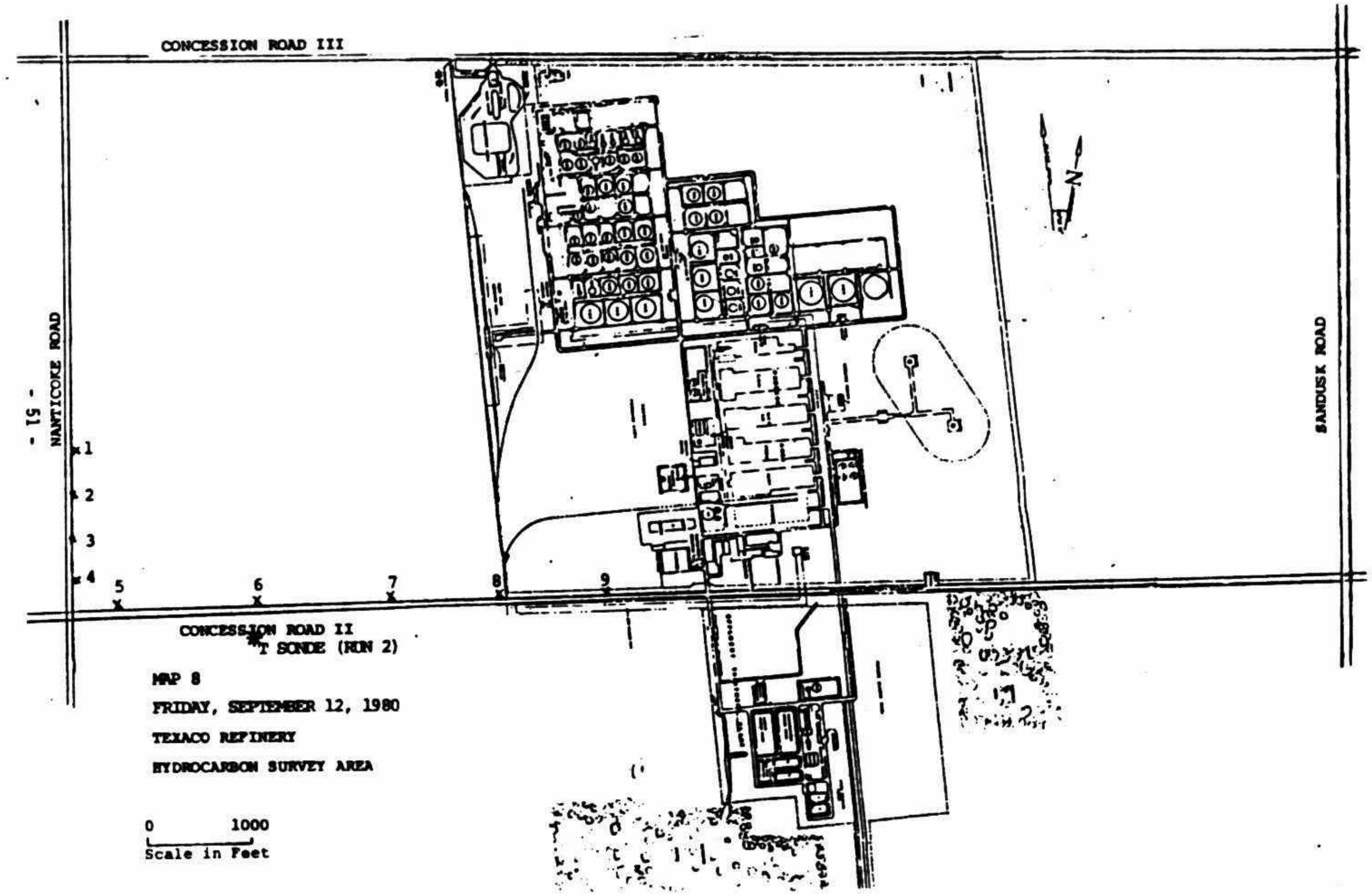


MAP 7
THURSDAY, SEPTEMBER 11, 1980
RUN 2

TEXACO REFINERY

HYDROCARBON SURVEY AREA

0 1000
Scale in Feet

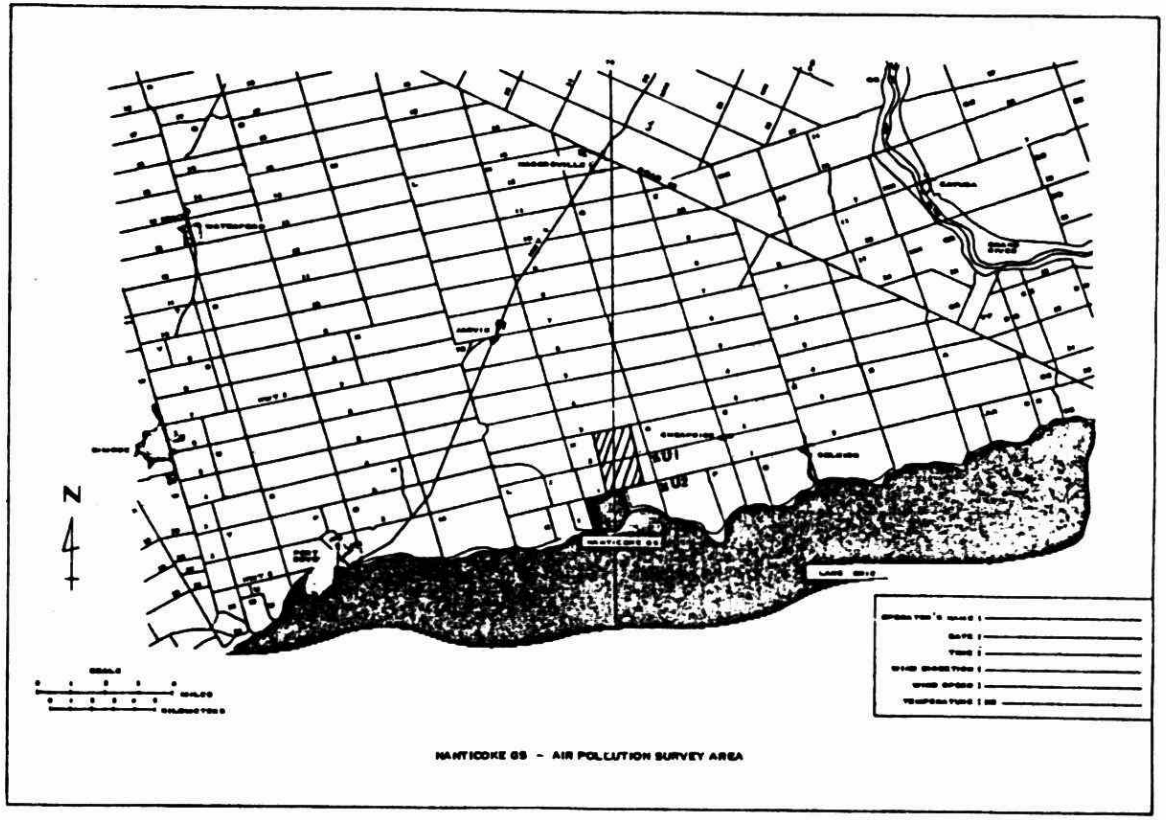


MAP 8

FRIDAY, SEPTEMBER 12, 1980

TEXACO REFINERY

HYDROCARBON SURVEY AREA



MAP 8A

FRIDAY, SEPTEMBER 12, 1980

UPWIND SAMPLING LOCATIONS

Appendix I

Description of Daily Sampling Conditions

Wednesday, September 3, 1980

Forecast: 0800 hrs - called for sunny and warm conditions with light NNW flows.

1200 hr update - winds shifting from NNW to SE remaining light.

Sampling Conditions: - During the morning the winds were light, from the north, so the NUTECH and tethersonde packages were set up along Concession Road II, south of the refinery. Between 1100 and 1200 hrs the plume tracker was able to pick up small traces of the refinery plume along Concession Road II near the eastern edge of the refinery. At 1200 the northerly flow started to subside, and by 1330 a definite south-southwest flow had developed, so the sampling packages were moved to the north side of the plant onto Concession Road III. It remained sunny and warm (T_{max} 24^{o}C) throughout the day.

Run 1 - Seven ground level NUTECH samplers with molecular sieve cartridges were spread out over 1 km on Concession III north of the refinery on the upwind side of the road (see Map 1). Three platforms with molecular sieve sampling packages were rasied on the second tethered balloon, however, the line supporting them broke shortly after sampling began causing the lower two samples to be lost. The elevated sample was collected at 35 m, however the height varied considerably as the ballon oriented itself in the wind. A single upwind sample was collected on a molecular sieve cartridge on Concession II just west of the refinery. The NUTECHS were all activated from 1550 to 1650 for one hour samples. Typical wind speeds during the hour were 3-5 ms^{-1}. There was very little vehicular traffic along Concession III in the sampling area, however there was some tank truck activity between Nanticoke Rd. and the TEXACO marketing area.

Thursday, September 4, 1980

<u>Forecast:</u> - 0800 Southerly flows were forecast for the entire day, with light winds increasing in the afternoon. The forecast also called for sunny and warm conditions.

<u>Sampling Conditions:</u> - The winds were southerly throughout the day, increasing in the afternoon. It was mainly sunny and warm, with some periods of light cloud in the early afternoon. The plume tracker traversed along Concession III during the morning, and detected a hydrocarbon plume in the vicinity of the west end of the tank farm. The downwind NUTECH samples were spread out over 1 km on the upwind side of Concession Rd. III (see Map 2) at least 10m upwind of the road. A single upwind NUTECH was placed south west of the refinery off Concession II. The meteorological balloon and the elevated hydrocarbon sampling platforms were deployed on the north side of the Concession Rd. III in the middle of the plume (as indicated by the plume tracker). Molecular sieve cartridges were exposed in all cases.

Run 1 - 1300 - 1400 hrs. The plume tracker was able to detect a plume coming from the west end of the tank farm, and it indicated that the centre of the plume was near NUTECH 5. The plume was well-defined and 300 m wide. Three elevated packages were used on the tethersonde which was located opposite NUTECH 5. The cartridges were exposed at heights of 105, 70 and 20m, although the heights varied considerably as the winds were gusting. The plume tracker indicated that the plume remained over the same location throughout the sampling period, and the elevated packages were in the plume. The winds remained steady from the south throughout the sampling period at 6-7 ms^{-1}.

Run 2 - 1500 - 1600 hrs - all NUTECH samplers and tethersonde samplers were located in the same locations as run 1. The plume tracker again indicated a well defined plume around NUTECH 5. The elevated packages were located at 100, 60 and 15 m above ground. During this run a curious Ontario Hydro helicopter flew very close to the balloon carrying the elevated packages, which may have led to some contamination of the airborne samples. Winds remained from the south at 7-8 ms^{-1}.

Friday September 5, 1980.

Forecast: - 0800 Mainly sunny with light flows from west - southwest becoming more westerly and increasing during the day.

Sampling Conditions - in the morning the winds were light from WSW indicating that sampling should occur in the north-east sector of the plant. At 1230 hrs a strong southerly flow (lake breeze?) started to develop so the samplers were moved north of the plant and set up along Concession Rd. III. At 1345 the wind was becoming more westerly, so the ground level NUTECH's were moved to the eastern side of the plant along Concession III. The easternmost NUTECH (N1) was in fact located in a swampy area behind a woodlot in the north east corner of TEXACO property. The tethersonde were set up on the north side of Concession III opposite the eastern edge of the tank farm.

Run 1 - Nine NUTECH samplers were set up downwind of the refinery on the upwind side of Concession III, spread from the eastern fence line of TEXACO 1 km west (Map 3). Two upwind samplers were collected, one on Concession III west of Nanticoke Rd. the other on Concession Rd IV west of Nanticoke Rd. (Map 3A). Elevated samples were attempted, however during the sampling period 1400-1500 hrs the wind shifted causing the platforms to move dangerously close to power lines, so the tethersondes were taken down. The wind shift caused the plume to move eastward along Concession III and as such the easternmost samples should show some hydrocarbon levels, although the plume tracker was still detecting some activity in the vicinity of the samplers 7 and 8 (possibly a plume fron the loading area). Winds were high during the sampling period (8-9 ms^{-1}) and by the end of the sampling period they had shifted to due west. All exposed cartridges were molecular sieve.

Monday September 8, 1980

Forecast: Light south to south easterly flows were forecast, with mainly sunny conditions in the morning, clouding over during the afternoon.

Sampling Conditions - during the morning the winds were calm, under sunny skies. At 1300 hrs light south-southwest flows began to develop, and by 1400 hrs the winds were 3-5 ms^{-1} from south-southwest. During both sampling periods molecular sieve cartridges were exposed in parallel with Tenax cartridges on NUTECHS with double sampling marifolds.

Run 1 - Upwind samples were collected west of Sandusk Rd. on Concession I (02 - Tenax and Molecular sieve) and Concession II (U1 - molecular sieve only). Nine ground level samplers were placed along Concession III north of the plant on the upwind side of the road (Map 4). NUTECHS 4,5,6,7 exposed TENAX and molecular sieve cartridges, while the others exposed only molecular sieve. Elevated molecular sieve cartridges were exposed at 120, 90 and 30 m on the north side of Concession III (opposite sample #5). The height of the platforms varied a great deal ($\pm$ 20m) due the varability of the winds. The plume tracker observed a very wide plume, often extending over the entire line of NUTECHS. The elevated packages were positioned in the centre of the plume for most of the sampling period. At the beginning of the sample period the sky was 50% overcast, by the end it had cleared to about 10% cloud cover.

Run 2 - All samplers remained in the same positions (including the elevated packages) and Tenax and molecular sieve cartridges were again exposed in parallel. The winds were slightly more westerly during this run at 3.5 ms^{-1} and the sky was clear throughout the run. The plume tracker found the plume to be at the western edge of the sampler line during this period (samples 5-8) in spite of the fact that the winds had become more westerly. The airborne packages were at heights of 100, 65, and 25m and again the heights varied. After the sample was collected, and the tethersondes lowered it was discovered that the bottom sampler may not have been turned off until it reached the ground (at about 1725).

Wednesday, September 10, 1980.

Forecast - 0800 Strong NW flows with mainly sunny conditions were forecast for the entire day.

Sampling Conditions - The forecast called for strong north westerly winds, so the tethersonde crew was not mobilized. The wind was from the north in the morning, shifting to north-west in the early afternoon. Duplicate molecular sieve cartridges were exposed to check the precision of the method.

Run 1 - Upwind samples were collected on the north side of Concession IV west of Nanticoke Rd. separated by 2 km (map 5a). Duplicate molecular sieve cartridges were exposed at u2. The nine downwind NUTECH samples were spread in an arc of 1.5 km along Concession Rd. II and on the south east corner of TEXACO property (Map 5). Duplicate molecular sieve cartridges were exposed at samplers 2,3,4,5, while single cartridges were exposed on the remaining NUTECHS. The plume tracker was able to see the plume along Concession II between the pipeline (NUTECH #7) and the eastern fence line of the refinery.

Thursday September 11, 1980

Forecast: 0900 mainly sunny with winds from west to west southwest at 15 knots, with gusts to 25 knots.

Sampling Conditions - The tethersondes were unable to fly due to the strong winds, which remained from the west - southwest throughout the day. Tenax and molecular sieve cartridges were exposed in parallel on all NUTECHS with double sampling manifolds. The upwind samples were collected along Concession Rd. II well west of the refinery (Map 6a). The downwind samples were collected at two downwind locations, a set of six along the abandoned runway on the eastern edge of TEXACO property, and a set of three along Sandusk Rd. in the vicinity of the Walpole South school. It was not possible to catch the northernmost edge of the plume due to the interference of a large wood to the north east of the tank farm. A bulldozer and two trucks were working on TEXACO property about 200 m upwind of samplers 1 and 2, and may have contaminated the samples. Prior to the run it was discovered that NUTECH #29 had no restricting orifices, thus invalidating all previous samples collected with this pump.

Run 1 - 1400 - 1500 hrs. The downwind NUTECHS were set up along the runway from the wooded area to the north past the crude tanks to the south. Initially the plume tracker was unable to detect any plume along Sandusk Rd., or on the runway east of the tank farm. There was, however, some signal on the photoionization detector directly under the flare stacks. The samplers along Sandusk Rd. were well upwind of the road (10 m).

Run 2 1600 - 1700 hrs. The NUTECH samplers along the runway were spread out more to the south in order that any emissions near the flare stack would be sampled. The plume tracker was again unable to find any plume with the exception of some signal near the flare stacks.

Friday September 12, 1980

Forecast - 0800 - overcast, with a chance of showers later in the day. Winds from east at 20 knots, shifting to SE in the afternoon.

Sampling Conditions - It was cool and overcast all day, with altocumulus cloud changing to stratus in the afternoon. The winds were shifting between east and north east throughout the day.

Run I - 1345 - 1445 hrs. The winds were from the east during the morning at 6 ms^{-1}. The tethersondes were set up along Nanticoke Rd. directly west of the tank farm. During the first run duplicate molecualr sieve cartridges were exposed up- and downwind to check the precision of the method. A check for breakthrough on the molecular sieve cartridges was also attempted by joining two molecular sieve cartridges in series for two of the samples. The upwind samples were collected east of Sandusk Rd. at Concession I and Concession II (Map 8a).

Run II - As the downwind samples were being placed along Nanticoke Rd. the wind shifted to North-Northeast. To facilitate sampling the entire width of the plume, samplers were set up north-south along Nanticoke Rd. and east-west along Concession II (Map 8). The tethersonde remained set up on Nanticoke Rd. in anticipation of a wind shift, but no airborne samples were collected during this run. The sample collected at position 8 was probably contaminated by a train that parked upwind of the pump for 10 min. The plume tracker was able to pick up a few small areas of plume, one at the corner of Naticoke Rd. and Concession II and another near the western edge of the TEXACO property. NUTECH 2 was located about 2 meters from the side of Nanticoke Rd. which remained quite busy during the sampling period.

Run 2 — 1600 - 1700 hrs. The tethersondes were moved to the south side of Concession Rd. II opposite NUTECH position #6 for this run. The weather remained cool and overcast during this run, however, the wind started to shift back to the east during the sampling period, suggesting that the elevated packages (100, 50, 30m) may have been in the edge of the plume. During this run, molecular sieve and Tenax cartridges were exposed in parallel in the up- and downwind locations. Position 8 was moved 50 m east to place it on the upwind side of the railroad tracks. Just after this run began, there was a shift change at TEXACO leading to heavy traffic along Concession Rd. II between 1600- 1610 hrs. After the sample was collected, but during the collection of the cartridges a light rain started to fall, possibly wetting the outside of some of the cartridges.